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J

J. The symbol for the Mechanical Equivalent of Heat.

Jaderin Wire. A thin wire some 24 m in length used in surveying for the measurement of distance.

Jaeger's Method. A practical method of measuring Surface Tension of a liquid at various temperatures. An air bubble is formed inside the liquid on the end of a glass Capillary tube of radius r. The excess pressure inside the bubble is measured and the surface tension γ determined from the formula

$$\gamma = rg(h\rho - h_1\rho_1)/2$$

h_1 is the depth of the end of the capillary below the surface of the liquid of density ρ_1 at temperature t_1 : h is the pressure gauge reading, ρ the density of the pressure gauge liquid and g the acceleration due to gravity. By repeating the experiment for various values of t_1, the variation of surface tension with temperature for the liquid can be determined.

Jamming. Radio reception interference such that the desired signal is unintelligible.

Jansky Noise. A high-frequency static disturbance of cosmic origin.

Jar. The name given to certain types of battery containers. For example, nickel-iron batteries (alkaline) contain a jar that is made of nickel-plated sheet steel. Since the jar on this type of battery is an electrical conductor, it must be insulated internally from the element and also from the battery posts where they pass through the top of the container. The insulation from the element is accomplished by hard rubber or plastic sheeting, and hard rubber bushings encircle the posts.

Jet. A long thin linear feature of bright emission extending from a compact object, such as a galaxy. Jets have been seen in radio, optical, and x-ray emission. They are sometimes broken up into a number of bright knots. An example is that found in the giant elliptical galaxy M87.

Jig Borer. A machine tool for the machining of accurately spaced holes and surfaces of component parts of jigs, fixtures, tools and gauges. It may also be modified to permit its use as an accurate measuring machine.

Jet Disintegration. The destruction of the jet structure and forward momentum owing to mixing which takes place at the jet boundaries and spreads into the jet core causing an outward spread of the flow.

Jet, Emulsion. A jet-like appearance in a nuclear emulsion arising from a nuclear interaction in which the incident particle has a very high energy (>100 GeV). (Note : $1eV \approx 1.6021 \times 10^{-19} J$).

Jet Flap. A thin sheet of air or gas discharged at high speed close to the trailing edge of a wing so as to induce lift over the whole wing independently of wing incidence. A shrouded jet flap is one in which the angle of discharge is controlled by means of a small flap along the trailing edge.

Jet Propulsion. Forward propulsion produced by one or more jets of high-velocity hot gas issuing from backwardly directed nozzles.

Jet, Pulse. A jet propulsion engine using a pulsating flow of atmospheric air into which fuel in injected and burned to produce a pressure buildup. Such an engine was used in the German V-1 bomb.

Jet, Ram. The simplest form of jet propulsion engine, using a steady flow of atmospheric air with ram (*i.e.* piston) compressions. It consists of intake diffuer, combustion chamber, and propelling nozzle, and is of particular value for flight at supersonic speeds but produces no static thrust.

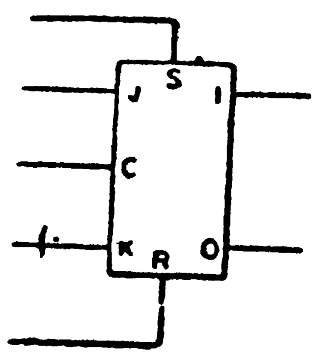
Jet Stream. A variable region of strong westerly wind occurring in the upper troposphere with maximum speeds of 50 or 100 m/s (100 or 200 mph). Two main jet streams occur, one in the northen hemisphere (the circumpolar jet stream) at up to about 10 km above sea level, and the other (the sub-tropical jet stream) extending round both hemispheres at a height of about 12 km.

Jet Tone. The variable hiss accompanying the emergence of a stream of moving air into still air.

Jeet. A bar of doped silicon, called a channel, that behaves as a resistor. The doping may be N or P type, creating either an N-channel or P-channel Jfet. There is a terminal at each end of the channel. One terminal is called the source, and the other is called the drain. Current flow between source and drain for a given drain source voltage is dependent on the resistance of the channel. This resistance is controlled by a gate. The gate consists of P-type regions diffused into an N-type channel or N-type regions diffused into a P-type channel.

As with any PN junction, a depletion region or an electric field surrounds the junction when reverse biased. As the reverse voltage is increased, the electric fields spread into the channel until they meet, creating an almost infinite resistance between source and drain.

J-K Flip-flop. A configuration readily adapted to integrated circuit applications that permits set/reset, toggle, and gated functions to be performed utilizing a single basic circuit. Fig., is the presently accepted logic symbol for such a flip-flop. As indicated by the diagram, the



Logic symbol for J-K flip-flop.

J-K flip-flop will usually have a minimum of five inputs and two outputs. The inputs are S, the preset connection; R, the reset connection; J, the set input; K, the clear input; and C, the clock or toggle input. The outputs are L, the set output; and O, the clear output.

Jog. In a dislocation line : the discontinuity or step formed where a dislocation line changes from one glide plane to a parallel glide plane, when the connecting length of dislocation line is about one atomic distance.

Johnson-rahbek Effect. The increase in frictional force between two electrodes in contact with a semiconductor, which occurs when a potential difference is applied. It is to be distinguished from the increase in frictional force arising from the attractive force between the electrodes. The effect has been applied in such devices as electromagnetic clutches.

Joly Block Photometer. A photometer consisting of two equal paraffin was blocks separated by a thin opaque sheet. The two light sources under comparison are arranged to illuminate one block each and their distances adjusted until the blocks appear equally bright.

Joly's Steam Calorimeter. An apparatus invented by John Joly (1857-1933) to measure the specific heat capacity of a gas at constant volume. Two equal spherical containers are suspended from the opposite ends of a balance arm. One sphere is evacuated and the other contains the sample gas. The whole apparatus is enclosed in a steam bath, the specific heat capacity of the sample gas being calculated from the difference between the masses of the water that condenses on each sphere.

Jordan Lag. A type of magnetic viscosity in which the angular lag of the induction behind the magnetic field, and also the energy loss per cycle, are independent of frequency.

Josephson Effect. The occurrence in two superconductors, separated by a thin dielectric, of an oscillatory current of frequency proportional to a steady potential difference applied between the conductors.

Joule. A unit of electrical measurement representing the work done by a difference of potential of 1 V (E) while moving 1 C (ϕ) of charge (6.28×10^{18} electrons). The equation can be stated as follows

$$J = E \times Q$$

Joule may also refer to a measurement of work that is done by a force by 1 N acting through a distance of 1m.

Joule Cycle. A reversible sequence of operations of a heat engine in which air is used as the working fluid. It consists of adiabatic compression, heating at constant pressure, adiabatic expansion, and cooling at constant pressure to the initial state.

Joule's Equivalent. Symbol : J. A constant, 4.1855×10^7 ergs per calorie (15°), relating former units of 'heat' energy to units of mechanical energy. It arose from early experiments by Joule showing the mechanical work always relates to an equivalent quantity of 'heat'. The constant is also called the mechanical equivalent of heat.

In SI units, work, heat, and all forms of energy are measured in joules. The value of J (4.1855 joules per calorie) is the factor defining the calorie.

Joule Experiment. An experiment designed to detect intermolecular attraction in a gas by the decrease in temperature observed when the gas is allowed to expand into a vacuum. The decrease arises from the loss in kinetic energy and gain in potential energy of the individual molecules.

Joule Heat. Also called joule effect, the thermal effect that results when electrical current flows through a resistance. It is measured in watts. When a current of 1 A flows through a resistance of 1 Ω, the joule heat given off is equivalent to 1 W. This is explained by Ohm's law for power, which reads

$$P - I^2R$$

where P is power in watts, I is current is amperes, and R is resistance in ohms.

Using this formula, when 2 A of current flow through a resistance of 1 Ω, the total power dissipation is 4 W.

Joule Heating. The production of heat in a conductor as a result of the passage of an electric current through the conductor. The quantity of heat produced is given by Joule's law.

Joule, International. The work done per second when a current of one international ampere is passed through a conductor whose resistance is one international ohm. It has now been superseded by the joule.

Joule-kelvin Coefficient. A quantity associated with the Joule-Kelvin Effect and equal to the rate of change of temperature with pressure at constant enthalpy.

Joule-kelvin Effect (Joule-Thomson effect). A temperature change that occurs when a gas expands through a porous barrier into a region of lower pressure. Most real gases, when expanded in this way, are cooled slightly because they do work against their own intermolecular forces.

An ideal gas would not show the Joule-Kelvin effect because there are no intermolecular forces. The phenomenon is the basis of a method of liquefying gases. The temperature fall depends on the difference in pressure across the plug.

The cooling shows a deviation from Joule's law. In addition, deviations of the gas behaviour from Boyle's law may cause either increase or decrease of temperature. At a certain temperature—the inversion temperature of the gas—the temperature rise from the second effect equals the drop produced by deviation from Joule's law, and there is no change in temperature. Below its inversion temperature a gas is cooled by the expansion; above it is heated.

Joule's Laws

1. The heat (Q) produced when an electric current (I) flows through a resistance (R) for a time (t) is given by $Q=I^2Rt$.

2. The internal energy of a given mass of gas is independent of its volume and pressure, being a function of temperature alone. This law applies only to ideal gases (for which it provides a definition of thermodynamic temperature) as in a real gas intermolecular forces would cause changes in the internal energy should a change of volume occur.

Joule Law of Electric Heating. States that the heat produced by an electric current, I, flowing through a resistance, R, for a time, t, is proportional to I^2 Rt.

Joule Law of Energy Content. For a perfect gas : states that the internal energy of a given mass of a perfect gas is a function of temperature only. This is also known as Mayer's hypothesis.

Joule-thomson Coefficient. For the Joule-thomson effect : the ratio of the change in temperature to the change in pressure.

Joule thomson Effect (Joule-Kelvin Effect). The change in temperature that occurs when a gas expands through a porous plug into a region of lower pressure. For most real gases the temperature falls under these circumstances as the gas has to do internal work in overcoming the intermolecular forces to enable the expansion to take place. This is a deviation from Joule's law. There is usually also a deviation from Boyle's law, which can cause either a rise or a fall in temperature since any increase in the product of pressure and volume is a measure of external work done. At a given pressure, there is a particular temperature, called the inversion temperature of the gas, at which the rise in temperature from the Boyle's law deviation is balanced by the fall from the Joule's law deviation. There is then no temperature change. Above the inversion temperature the gas is heated by expansion, below it, it is cooled. The effect was discovered by James Joule working in collaboration with William Thomson (later Lord Kelvin; 1824-1907).

Jovignot Test. A test carried out to determine the ductility of a metal sheet, in which a circular plate is clamped at the

edges and subjected to fluid pressure on one side. Measurements are made of the fractional increase in surface area necessary to produce fracture.

Joystick. A manual input control device for graphic display consoles that allows the user to control the coordinates of a point of light on the screen. By driving the cursor around the screen, freehand drawings may be made in electronic graphic form. Graphics computers and many video games incorporate joysticks. For example, in a TV tennis game, each opponent controls a joystick, which, in turn, aligns the electronic cursors at different coordinates in order to repel the automatically controlled cursor, which corresponds to the tennis ball. The joystick cursors repel the ball.

Joysticks normally consist of a small lever that moves vertically and horizontally (and sometimes diagonally). The cursor on the visual display screen moves in accordance with the physical position of the joystick.

J/psi Particle. A Meson of mass 3 giga-electronvolt, composed of a charmed Quark and a charmed antiquark. Its discovery gave support to Electroweak Theory and the Charm concept, and impetus to the development of Strong Interaction theory.

Jugfet. Transistor.

Jovian Planets. A term derived from the Latin name for Jupiter and applied collectively to the giant planets Jupiter, Saturn, Uranus, and Neptune.

Julian Calendar. The calendar that was established in 46 BC in the Roman Empire by Julius Caesar, with Sosigenes of Alexandria as his chief advisor. It reached its final form in about 8 AD under Augustus and was in general use in the West up to 1582, when the Gregorian calendar was instituted. Each year contained 12 months and there was an average of 365.25 days per year : three years of 365 days were followed by a leap year of 366 days. (Leap years were not correctly inserted until 8 AD). Since the average length of the year was about 11 minutes 15 seconds longer than the 365.2422 days of the tropical year,

a discrepancy arose between the calendar year and the seasons, with an extra day 'appearing' about every 128 years.

Julian Date. The date expressed in terms of the number of days since an arbitrary zero date 1st January 4713 B.C. Julian days are used to express the times of most astronomical observations and are reckoned from noon, a portion of a day being expressed as a decimal to the required degree of precision. The name Julian is derived from that of Julius Scaliger, the father of J.J. Scaliger who introduced the system in 1582. There is no connection with the Julian calendar.

(Note. On Ist January 1971 the Julian date was 2 439 951).

Julian Year. A period of 365.25 days (each containing 864 000 seconds, *i.e.*, 24 hours). A Julian century is 100 Julian years. The Julian year has been used since 1984 for defining standard epochs, replacing the Besselian year. It is denoted by the prefix J, as in J2000.0.

Junction Detector (solid-state detector). A sensitive detector of ionizing radiation in which the output is a current pulse proportional to the energy falling in or near the depletion region of a reverse-biased semiconductor junction The first types were made by evaporating a thin layer of gold on to a polished wafer of n-type germanium; however, gold-silicon devices can be operated at room temperature and these have superseded the germanium type, which have to be operated at the temperature of liquid nitrogen to reduce noise. When the gold-silicon junction is reverse-biased a depletion region, devoid of charge carriers (electrons and holes), forms in the silicon. Incoming ionizing radiation falling in this depletion region creates pairs of electrons and holes, which both have to be collected in order to give an output pulse proportional to the energy of the detected particle.

Junction detectors are used in medicine and biology as well as in space systems.

Junction Diode. A semiconductor device created by joining an N-type region and P-type region of a crystalline material,

such as germanium or silicon. The junction diode has four important ratings that must be taken into consideration. These are the maximum average forward current, maximum repetitive reverse voltage, maximum surge current, and maximum repetitive forward current. These ratings are important when it becomes necessary to troubleshoot a circuit or to select junction diodes for replacement when the desired one is not readily available.

The maximum forward current is the maximum amount of average current that can be permitted to flow in the forward direction. This rating is usually given for a specified ambient temperature and should not be exceeded for any length of time, as damage to the diode will occur. The maximum repetitive reverse voltage is that value of reverse bias voltage that can be applied to the diode without causing it to break down.

The maximum surge current is that amount of current allowed to flow in the forward direction in nonrepetitive pulses. Current should not be allowed to exceed this value at any time and should only equal this value for a period not to exceed one cycle of the input. The maximum repetitive forward current is the maximum value of current that may flow in the forward direction in repetitive pulses.

All of the ratings mentioned are subject to change with temperature variations. If the temperature increases, the ratings given on the specification sheet should all be lowered, or damage to the diode will result.

Junction, Hybrid. A type of waveguide circuit with four branches which, when the branches are properly terminated, has the property of enabling energy to be transferred from any one branch into only two of the remaining three.

Junction, P-N. Semiconductor junctions.

Junction Rectifier. Rectifier.

Junction Transistor. Short for bipolar junction transistor.

Jupiter. A Giant Planet of diameter 142 800 kilometre. Its mass is 315 times that of the Earth but its density only one fifth of Earth's. Its gravity is 2.5 times and its magne-

tic field about 17 000 times those of Earth. Jupiter is 778 million kilometre from the Sun and is the fifth planet out from it. Its orbital and average axial rotation periods are 11.86 year and 9 hour 51 minute respectively. Jupiter's atmosphere consists of hydrogen, helium, methane, ammonia and nitrogen. The southern hemisphere is characterized by what is known as the Great Red Spot. The planet and its satellites have been the subject of investigation by US space probes.

Juvin's Rule. The formula

$$h=2\gamma \cos \alpha/(rg\rho)$$

where h is the difference in height between the level of liquid inside and outside a vertical open-ended capillary tube, internal radius r, standing in the liquid; ρ and γ are respectively the density and surface tension of the liquid, g is the acceleration due to gravity and α is the Angle of Contact between the liquid surface and the capillary tube wall. For liquids which wet the tube, α is less than 90° and so cos α is positive; these liquids therefore rise in a capillary tube. For liquids which do not wet the tube, α is greater than 90° and so cos α is negative; such liquids therefore fall below the general liquid level outside the tube.

K

K. The symbol for the Boltzmann Constant.

Kaon (K-meson). A type of meson. There are two types of kaon, having negative or positive charge.

Kapitza Liquefier

1. A hydrogen liquefier, employing Joule-Thomson expansion after precooling with liquid nitrogen.
2. A helium liquefier employing, after precooling with liquid nitrogen, a gas-lubricated single-cylinder reciprocating engine.

Kapteyn Selected Areas. Areas selected as the basis of a system of sampling in the study of faint stars owing to the prohibitive cost, both in time and money, of making a complete catalogue.

Kapteyn Universe. An early model of the Galactic System which has now been superseded.

Karman Boundary Layer Theorem. States that the rate of change of momentum across an area between a boundary layer of a fluid and the surface is equal to the sum of the difference of the pressures across the area, and the skin friction.

Karman Similarity Theory. Of turbulent flow in fluids : states that the local flow pattern is statistically similar at or near all points in the fluid, only the time and length scales being different.

Karman-Tsien Method. A Method of approximating to the equations for compressible fluid motion in two dimensions, which leads to a simple rule for the estimation of compressibility effects in subsonic flow.

Karman Vortex Street. A regular arrangement of vortices situated alternately in two parallel rows as are street lamps. Such a vortex street resembles a double trail of vortices in the wake of a bluff cylinder in a certain range of Reynolds number, and was proposed by von Karman as a mechanism for the drag of a solid body in the flow of a fluid of small viscosity.

Karnaugh Map. A logic chart showing switching-function relationships in digital computers. It is used in computer logic analysis to determine speedily the simplest form of logic circuit to use for a given function. The Karnaugh map is sometimes regarded as a tabular form of the more conventional Venn diagarm.

Katabatic Wind. A wind caused by the downward motion of the air, *e.g.* by cold air flowing into a valley from high ground. Such winds are common in desert ravines and may reach very high speeds.

Kater's Pendulum. A complex pendulum designed by Henry Kater (1777-1835) to measure the acceleration of free fall. It consists of a metal bar with knife edges attached near the ends and two weights that can slide between the knife edges. The bar is pivoted from each knife edge in turn and the positions of the weights are adjusted so that the periods of the pendulum is the same with both pivots. The period is then given by the formula for a simple pendulum, which enables g to be calculated.

Katharometer. An instrument for comparing the thermal conductivities of two gases by comparing the rate of loss of heat from two heating coils surrounded by the gases. The instrument can be used to detect the presence of a small amount of an impurity in air and is also used as a detector in gas chromatography.

K-beta Filter : Beta Filter. A filter used in X-ray diffraction studies to remove essentially all the $K\beta$ radiation from a beam of characteristic K X-rays. It usually takes the form of a foil of an element which has an absorption edge between the $K\alpha$ and $K\beta$ wavelengths.

Keeper. A piece of soft iron used to bridge the poles of a permanent magnet when it is not in use. It reduces the leakage field and thus preserves the magnetization.

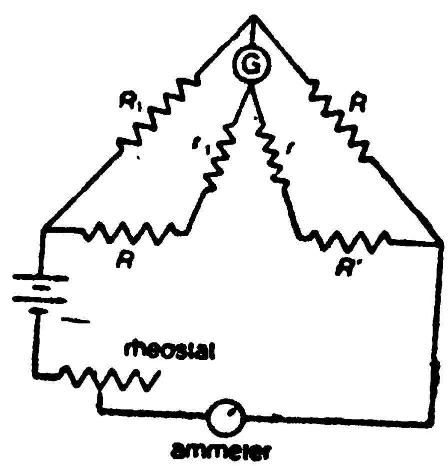
Kellner Eyepiece. A variaty of Ramsden Eyepiece having a cemented eye lens which corrects for chromatic abberation and distortion more successfully than the original. The eyepiece is mainly used in prism binoculars.

Kelvin Symbol : K The SI base unit of thermodynamic temperature. It is defined as the fraction 1/273.16 of the thermodynamic temperature of the triple point of water. Zero kelvin (0 K) is absolute zero. One kelvin is the same as one degree on the Celsius scale of temperature.

Kelvin Balance. A type of Ampere Balance.

Kelvin Contacts. A method of testing electronic circuits and components whereby the effect of lead resistance on the measurements is eliminated.

Kelvin Double Bridge. A type of Wheatstone Bridge, illustrated in fig. used for accurate measurement of a low resistance R. The resistance R′ is of the same order as R. The



Kelvin double bridge

relationship

$$R_1/R_2 = r_1/r_2$$

is maintained throughout but its value is changed until the galvanometer G indicates zero current. The ratio value is then R/R′. The effects of errors due to contact and lead resistances are eliminated.

Kelvin Effect. Another name for Thomson Effect.

Kelvin's Formula. The formula

$$T=2\pi(LC)^{1/2}$$

where T is the period, L the inductance and C the capacitance in an electric circuit of negligible resistance.

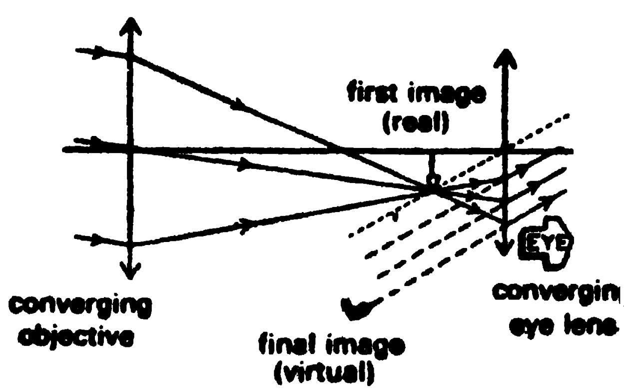
Kelvin's Temperature. Any temperature in the absolute scale. This is a temperature scale with its zero point at -273.1°C, or absolute zero. The unit of thermodynamic temperature is the kelvin, and its symbol is K.

Kennelly-Heaviside Layer : Heaviside : Layer : E-layer. The lower of the two main strata or "layers" in the ionized atmosphere, the other being the Appleton or F-layer. It occurs at a height of about 100 km.

Kenotron. A high-voltage (above 10 kV) thermionic diode rectifier.

Keplerian Telescope. The most common type of refracting telescope arrangement, consisting of converging objective and eyepiece. Unlike the Galilean telescope, it provides an inverted image and has a greater length. However the field of view is larger and image quality is higher.

The angular magnification is given by f_O/f_E; the lens separation is (f_O+f_E). For terrestrial use an inverting lens can be included between the objective and the



Keplerian telescope

eyepiece. This is placed so that it is a distance $2f_I$ (f_I is its focal distance) from the first image formed by the objective. An erect image is formed a distance 2f behind the inverting lens, arranged to be at the

principal focus of the eyepiece. The magnification is not affected but the distance from objective to eyepiece is now $f_O + f_E + 4f$.

Kepler Laws. Three laws which initiated the modern mathematical treatment of planetary motions. They may be stated as follows : (a) Every planet moves in an ellipse of which one focus is the Sun. (b) The radius vector from the Sun to a planet sweeps out equal areas in equal times. (c) The squares of the periodic times which the various planets take to describe their respective orbits are proportional to the cubes of their mean distances from the Sun, the mean distance being taken as the length of the semi-major axis.

Kepler Telescope. A refracting astronomical Telescope whose objective and eyepiece are both convex lens systems. When used in normal adjustment the focal points of the two systems coincide. To convert the instrument to a terrestrial telescope an erecting prism is inserted in the system.

Kerma. The ratio of the sum of the initial kinetic energies of charged particles indirectly produced by ionizing radiation in a small mass of substance, to that mass.

Kerr Cell. A fast optical shutter employing the Kerr effect. It consists essentially of a cell containing an optically transparent isotropic material (solid or liquid) and a pair of plates for applying a large electric field across it. Between crossed nicol prisms (or crossed polaroids) no light passes through the cell until the field is turned on. Such cells have been employed in television equipment, in the determination of the speed of light and in measuring the decay times of fluorescent phenomena.

Kerr Effect

1. An electro-optical effect in which Double Refraction is induced in some liquids and gases when subjected to a strong electric field perpendicular to the direction of illumination. If n_1 and n_2 are respectively the

refractive indices for the ordinary and extraordinary rays, then

$$n_1 - n_2 = k\lambda E^2$$

where λ is the wavelength of the radiation used. E, is the electric field strength magnitude and k is Kerr's constant. A practical application of the effect is in the Kerr cell, which is a transparent device containing a suitable liquid and two electrodes and which behaves as a shutter : a beam of plane polarized light incident on a Kerr cell can be stopped by applying a suitable voltage across the electrodes.

2. A magneto-optical effect in which a beam of plane polarized light striking the polished pole face of an electromagnet shows slight elliptical polarization after reflection there.

Kersten Theory. A theory, now superseded, which explained the existence of non-zero coercive forces in ideal bulk ferromagnetic material as arising from the existence of non-magnetic inclusions located at the corners of a simple cubic lattice.

Ke V. Kiloleectronvolts; 10^3 electronvolts.

Kew Magnetometer. A Magnetometer employing a steel tube as magnetic needle. A convex lens is mounted at one end of the tube and a graduated transparent scale, which lies in the focal plane of the lens, at the other end. The scale is observed through a telescope in normal adjustment. The instrument is used to make accurate measurements of the Earth's magnetic field.

Kilo. Symbol : k A prefix denoting 10^3. For example, 1 kilometre (km)$=10^3$ metres (m).

Kilocycle A former unit of frequency equal to 1000 hertz.

Kilogramme. The unit of mass in the MKS and International (SI) systems. It is the mass of a standard platinum-10% iridium alloy in the form of a cylinder which is kept at the Bureau International des Poids et Mesures in Sevres.

Des Archives. The original prototype kilogramme, intended to represent the mass of a cubic decimetre of pure water at its temperature of maximum density (4°C), of which the standard kilogramme is an exact copy. The volume of 1 kg of water at 4°C is, however, 1.000 028 dm^3, so that the standard kilogramme is 28 mg heavier than was intended. The litre, which was formerly defined as the volume of 1 kg of pure water at 4°C, is on this basis equal to 1.000 028 dm^3. It has, however, been redefined by the CGPM (Conference Generaledes Poids et Mesures) as 1.000 dm^3 exactly, with the recommendation that neither the word "litre" nor its symbol "l" should be used to express results of high precision.

Kilohertz. A unit of frequency that is equivalent to 1000 Hz, or 1000 cycles/s. Abbreviated kHz.

Kilometre. Symbol km. A unit of length equal to 1000 metre.

Kiloton Weapon. A nuclear weapon with an explosive power equivalent to one thousand tons of TNT. Compare megaton weapon.

Kilowatt. Symbol kW. A unit of power equal to 1000 watt.

Kilowatt-hour. Symbol kWh. The commercial unit of electrical energy. It is equivalent to a power consumption of 1000 watts for 1 hour.

Kinematic Design of Instruments. A technique or techniques for the maintenance of correct positional relationships between component parts. A classic example is the Kelvin clamp for the location of an instrument, having three ball feet resting on a plane surface which carried a "hole and a slot", now usually a trihedral hollow and a vee-groove.

Kinematic (or Kinetic) Potential : Lagrangian Function. The difference between the kinetic energy and potential energy of a dynamic system. This function enables the equations of motion of classical mechanics and Hamilton's principle to be written in a simple form.

Kinematics. The branch of mechanics concerned with the motions of objects without being concerned with the forces that cause the motion. In this latter respect it differs from dynamics, which is concerned with the forces that cause motion.

Kinematic Viscosity. Symbol : v. The ratio of a fluid's viscosity to its density.

Kinescope. Any device containing a cathode-ray tube used to form pictures or visual displays from an electronic signal This is an old term that is rarely used in modern terminology.

Kinetic Effect. A chemical effect that depends on reaction rate rather than on thermodynamics. For example, diamond is thermodynamically less stable than graphite; its apparent stability depends on the vanishingly slow rate at which it is converted. Overvoltage in electrolyitc cells is another example of a kinetic effect. Kinetic isotope effects are changes in reaction rates produced by isotope substitution. For example, if the slow step in a chemical reaction is the breaking of a C—H bond, the rate for the deuterated compound would be slighly lower because of the lower vibrational frequency of the C—D bond.

Kinetic Energy. Energy stored in a system by virtue of the velocities of various moving masses within the system. The kinetic energy of a body of mass m and velocity v is $\frac{1}{2}mv^2$.

Kinetic Energy Density. The Kinetic Energy per unit volume.

Kinetic Head : Velocity **Head**. For a perfect fluid in steady flow : one-half the ratio of the square of the flow velocity to the gravitational acceleration. It is the height of a column of fluid giving a hydrostatic pressure of $\frac{1}{2}\rho v^2$, where ρ is the density and v the flow velocity. Pressure head+Velocity (or Kinetic) head+Elevation head= constant, according to the Bernoulli equation.

Kinetics

1. The study of rates of chemical reactions. It yields information on reaction mechanisms.
2. The Dynamics of material bodies.

Kinetic Theory of Gases. The theory which relates the macroscopic properties of a gas to the motion of its individual molecules. It assumes that heat can be identified with molecular motion, that the molecules can be regarded as elastic spheres, that the interaction of gas molecules with each other and with the walls of the container may be treated according to the laws of classical mechanics, and that the methods of statistical analysis may be used.

Kinetic Theory of Matter. A theory relating the motion of individual molecules to the macroscopic properties of a substance. For solids, intermolecular forces are so large that molecular motion is mainly confined to vibration about a fixed position. Application of kinetic theory leads to Dulong and Petits Law. For liquids, attractive forces between molecules are smaller than for solids so that the molecules move around at random mainly inside the liquid.

Kirchhoff's Current Law. The law that states that the algebraic sum of the currents entering and leaving a junction of conductors is equal to zero. That is

$$I_1+I_2+I_3+\ldots=0$$

where I_1, I_2, I_3, etc., are the currents entering and leaving the junction. Currents entering the junction are assumed to be positive, while currents leaving the junction are negative. When solving a problem using this equation, the currents must be placed into the equation with the proper polarity signs attached.

Kirchoff's Law. For a given wavelength the emissivity of a surface in a particular direction is equal to the absorptance for radiation incident from that direction.

Kirchhoff's Laws. A set of rules for calculating unknown currents, resistances, and voltages in an electric circuit. They are :

1. The algebraic sum of the currents at any point in any circuit is zero. For example, if 6 amperes enter a three-way junction through one wire, then 6 amperes must leave through the other two. A current flowing away from a junction has an opposite sign to one flowing towards the junction.

2. The algebraic sum of the e.m.f.s round any closed loop in any circuit is equal to the sum of the products of current and resistance around the loop. For example, in a circuit with e.m.f. E, current I, and resistances R and r, $E=Ir+IR$.

Kirchhoff Radiation Law. States that the ratio of the emissive power to the absorptive power for thermal radiation of a given wavelength is the same for all bodies at the same temperature and is equal to the emissive power of a black body at that temperature.

Kirchhoff Vapour Pressure Formula. For the variation of vapour pressure with temperature.: may be stated as $\ln p=A-(B/T)-C \ln T$, where p is the vapour pressure, T the temperature, and A, B and C are constants. It is valid only over a limited range of temperature.

Kirkendall Effect. The shift in the interface between two metals or alloys, bonded together by, say, pressure welding or electrodeposition, when they are annealed to allow the two to diffuse into one another. It is sometimes known in the French literature as the Smigelskas effect.

Klein-gordon Equation. A relativistic form of the Schrodinger Equation, used in nuclear quantum theory :

$$\nabla^2\psi+[(E-V)^2-m^2c^4]\psi/(h^2c^2)=4\pi\rho$$

where ψ is the Schrodinger wave function, E the total particle energy, V the potential energy, m the rest mass of the particle, c the speed of light in vacuo, h the Planck

constant and ρ a quantity proportional to the nvcleon density.

Klein-nishina Formula. An expression for the total or differential cross-section of an unbound electron for the Compton scattering of a photon, according to Dirac's electron theory.

Klystron. An electron tube that generates or amplifies micro-waves by velocity modulation. Several types are used; in the simple two cavity klystron a beam of high-energy electrons from an electron gun is passed through a resonant cavity, where it interacts with high-frequency radio waves. This microwave energy modulates the velocities of the electrons in the beam, which then enters a drift space where the faster electrons overtake the slower ones to form bunches. The bunched beam now has an alternating component, which is transferred to an output cavity and thence to an output waveguide.

K Meson. A variety of strange Meson.

Knife Edge. A sharp wedge used as a fulcrum or support, as in a balance. The sharp tip minimizes the area of contact between moving parts, thereby reducing the friction between them. Knife edges are made of hard material such as agate.

Knight Shift. The fractional increase in the magnetic resonance frequency of an atomic nucleus in a metal relative to that of the same nucleus in a non-metallic compound in the same external magnetic field. It is a function of the spin paramagnetism of the conduction electrons and their magnetic coupling to the nuclei.

Knocking. The metallic sound produced by a spark-ignition petrol engine under certain conditions. It is caused by rapid combustion of the unburnt explosive mixture in the combustion chambers ahead of the flame front. As the flame travels from the sparking plug towards the piston it compresses and heats the unburnt gases ahead of it.

Knock-on Particle. A particle which is displaced or recoils after a collision with an energetic particle moving through matter. A knocked-on atom may possess sufficient energy to displace other atoms.

Knee : The bend in a response curves that is most often an indication of the onset of saturation or cutoff.

Knot. A unit of speed equal to 1.15 mile per hour. It is used for expressing the speed of ships and aircraft.

Knudsen Flow. The flow of gas through a long tube at pressures such that the mean free path of the gas molecules is much greater than the radius of the tube.

Knudsen Gauge. A device used to measure very low gas pressures for which the mean free path of the molecules is large compared with the apparatus dimensions. Gas molecules, after striking electrically heated stationary plates, temperature T_1, and then a cooler rotatable vane structure of temperature T_2, produce a resultant torque on the vane. The pressure can be calculated from the observed vane deflection θ and equals

$$k\theta/[(T_1/T_2)^{1/2}-1]$$

where k depends on the torsional constant of the vane suspension.

Knudsen Number. A parameter λ/L, where λ is the mean free path of the molecules and L is a characteristic length, which is important in the case of fluid flow of low molecular density.

Kohlrausch's Law. If a salt is dissolved in water, the conductivity of the (dilute) solution is the sum of two values—one depending on the positive ions and the other on the negative ions. The law, which depends on the independent migration of ions, was deduced experimentally by the German chemist Friedrich Kohlrausch (1840-1910).

Kovar. A tradename for an alloy of iron, cobalt, and nickel with an expansivity similar to that of glass. It is therefore used in making glass-to-metal seals, especially in

circumstances in which a temperature variation can be expected.

Kramers Theorem. States that the lowest energy level in a paramagnetic material is degenerate if the magnetic ions have an odd number of electrons, and that the degeneracy is at least two-fold.

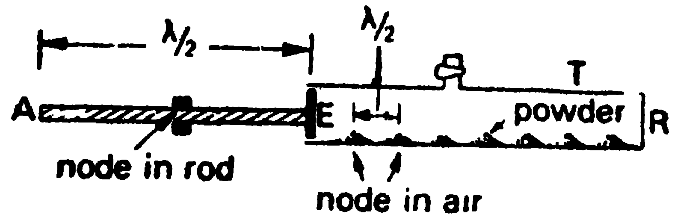
Kundt Law of Abnormal Dispression. When the refractive index of a solution increases, *e.g.*, because of change of composition, its optical absorption bands are displaced towards the red. This law does not always hold in practice.

Kundt's Rule. The refractive index of a medium does not vary continuously with wavelength in the region of absorption bands.

Kundt's Tube. A device for showing stationary waves in a gas (or liquid). A horizontal rod, clamped at its midpoint, has a flat disc on one end. The disc just fits into the bore of a glass tube, which is closed at the other end with a flat surface. Fine powder is sprinkled along the inside of the tube. The rod is stroked to produce longitudinal vibrations; sound waves are generated by the disc, travel down the tube, and are reflected at the closed end. The position of the disc is changed (changing the length of the column of gas) until standing waves are produced. The dust then vibrates strongly and settles in regularly-spaced heaps along the tube. These are nodes.

The device can be used to find the speeds of sound in different materials. It can be shown that :

$$V_r = l_r V_g / l$$



Dust Tube

where V_r is the speed of sound in the rod, V_g the speed in the gas, l_r the length of the rod, and l the distance between nodes in the gas. Similar experiments can be performed by replacing the rod and disc with a loud-speaker connected to a variable signal generator.

Kurie Plot : Fermi Plot. Of a β-particle spectrum : a graph in which a suitable function of the observed intensity is plotted against the particle energy, the function being chosen so that the graph is a straight line for allowed β-transitions. It is used in determining the character of the β-transition and the maximum energy.

Kutta-Joukowski Hypothesis. In the theory of the uniform flow of a fluid past two-dimensional aerofoils : provides a criterion for specifying the circulation round a closed contour at a large distance from the aerofoil, which must be satisfied to permit a satisfactory analytical study to be made.

L

Label. A radioactive atom in a molecule, used to monitor the behaviour of the molecule.

Labyrinth Loudspeaker. A loudspeaker whose enclosure (wooden cubicle) includes a folded pipe or acoustic transmission line behind the speaker. The inner walls are lined with a sound-absorbent material. When the pipe, which is open ended, is half as long as the wavelength of the frequency being reproduced, the sound emerging from the open end is in phase with that radiated by the front of the speaker and therefore reinforces it. Because there is no sudden change in pressure as the sound leaves the pipe, the pipe produces no antiresonance.

Ladder Filter. A series of identical fourterminal symmetrical networks connected together to yield a Transmission Line with continuously repeated impedance sections.

Ladder Network. A series of identical symmetrical four-terminal networks connected together to form a line with continuously repeated impedance sections.

Laevorotatory. Designating a chemical compound that rotates the plane of plane-polarized light to the left (anticlockwise for someone facing the oncoming radiation).

Lag

(1) The interval of time, or the angle, by which a specific phase in one periodically varying quantity is delayed with respect to the same phase in a similar quantity. There may for example be a lag between an alternating current and the electromotive force producing it, or *vice versa*. Compare Lead.

(2) The time interval between transmission and reception of a signal.

Lagging

(1) The use of materials of low thermal conductivity to hinder the passage of heat from hot bodies (*e.g.* a steam boiler) or to cold ones (*e.g.* in refrigerating plant).

(2) Short for lagging material.

Lagging Current. The steady-state current in an a.c. circuit, the maximum of which, owing to inductive reactance, lags behind the maximum of the applied voltage.

Lagging Load. A load (2) carrying a Current lagging behind the electromotive force producing it. An example is an Inductor.

Lagrange Brackets. The expression

$$\sum_{r=1}^{n}\left(\frac{\partial q_r}{\partial u}\frac{\partial p_r}{\partial u}-\frac{\partial p_r}{\partial u}\frac{\partial q_r}{\partial v}\right)$$

where $q_1 \ldots q_n$ and $p_1 \ldots p_n$ are functions of two variables u and v, and possibly other variables. It plays a big part in the theory of partial differential equations and, in particular, in analytical dynamics.

Lagrange's Equations. Second-order differential equations expressing the relationship between the Lagrangian Function L of a system of particles, the generalized co-ordinates q_i, the generalized forces Q_i and the time t :

$$d/dt[\partial L/\partial q_i] - \partial L/\partial q_i = Q_i$$

where $i = 1, 2, \ldots n$, and n is the number of degrees of freedom of the system.

Lagrangian Function. Symbol L. The kineus energy of a system minus its potential energy.

Lalande Cell. A primary Cell having zinc and iron electrodes, a caustic-soda solution electrolyte and using copper oxide for depolarization.

Lambda Leak. A leak of liquid helium II through small holes impassable for normal liquids. It is also known as a superleak.

Lambda Particle. An uncharged elementary particle classified as a Hyperon of mass 2183 times the electron mass. It can replace a neutron in a nucleus yielding an extremely unstable hypernucleus.

Lambda Point. Symbol λ. The temperature of 2.186 K below which helium becomes a superfluid.

Lambert. A former unit of 'luminance equal to the luminance of a uniformly diffusing surface that emits or reflects one lumen per square centimetre. It is approximately equal to 3.18×10^{3} Cd m^{-2}. It is named after Johann H. Lambert (1728—77).

Lambert's Law

1. First proposed in 1760; then restricted to visible light, it is now used with all radiations. The law concerns the rate of absorption of radiation as it travels deeper into a medium. It states that equal thicknesses of the medium absorb equal proportions of the incident radiation. In other words, the intensity I of the transmitted radiation falls off exponentially with distance d in the medium :

$$I = I_0 \exp{-\alpha d}$$

Here I_0 is the intensity of the initially incident radiation, and α is the linear absorption coefficient of the medium. As well as depending on the medium, α varies with wavelength.

2. In photometry, the fact that the luminous intensity of a diffuse surface varies with angle of view :

$$I_0 = I_0 \cos\theta$$

Here, I_0 is the intensity along the normal, while I is that along a line at angle θ to the normal. The principle is often called Lambert's cosine law.

Lamb-retherford Shift. The difference between the positions of atomic energy levels as calculated by the Dirac theory and by quantum electrodynamics. It arises from the neglect by Dirac of the interaction of electrons with the radiation field.

Lamb Shift. A small energy difference between the energy levels of the $^2P_{1/2}$ and $^2S_{1/2}$ states of hydrogen, which arises from interaction between the electron and the radiation field.

Laminar Flow. Steady flow in which the fluid moves past a surface in parellel layers of different velocities. Compare turbulent flow.

Laminar Flow Control. Boundary layer control, especially at high speeds.

Laminated Core. A core for a transformer or other electrical machine in which the ferromagnetic alloy is made into thin sheets (laminations), which are oxidized or varnished to provide a relatively high resistance between them. This has the effect of reducing eddy currents, which occur when alternating currents are used.

Laminated Iron. A piece of iron constructed in thin layers that are separated by electrical insulator. Laminated iron cores are used in many electric machines. The laminations reduce eddy currents caused by a changing magnetic field.

Lamination. A form of construction used for the cores of transformers, transducers, relays, chokes and similar alternating current apparatus. The core is made of thin strips of surface-oxidized or varnished iron or steel so that it presents a high resistance to Eddy Currents.

Lamp. Originally a source of light in which liquid fuel and a wick were used. It now denotes any artificial source of light, whether for home and street lighting, or for scientific purposes.

Lamp, Arc. A lamp which consists essentially of electrodes between which an electric arc is maintained.

Lamp, Atomic Beam. A lamp in which the light is produced by exciting the atoms in an atomic beam, thus producing light which covers a small spectral range.

Lamp, Cadmium Vapour. A cadmium vapour discharge lamp giving several spectral lines of which the red line was formely used as a wavelength standard.

Lamp, Carcel. The former French standard lamp. It burned colza oil and used a wick.

Lamp, Ceramic. Essentially consists of an electroluminescent panel in which a specially prepared zinc sulphide phosphor is sandwiched between two conducting sheets (one of which is transparent). This panel emits light when subjected to the effect of an a.c. electric field.

Lamp, Comparison. A lamp having constant but not necessarily known luminous intensity, with which a standard lamp and a light source under test are successively compared by means of a photometer.

Lamp, Daylight. A lamp giving light with the same spectral quality as sunlight from a moderately overcast sky, as far as is possible.

Lamp, Discharge. A lamp which consists essentially of a tube filled with gas or vapour, containing two electrodes between which a discharge passes.

Lamp, Electric. A generic term including filament or incandescant lamps on the one hand and discharge lamps on the other.

Lamp, Electrodeless. A lamp in which a ring discharge is formed by the action of an intense high-frequency magnetic field in which the lamp is placed.

Lamp, Fluorescent. A mercury vapour discharge lamp producing ultraviolet light which is converted to visible light by the excitation of a layer of fluorescent salt deposited on the inner surface of the tube.

Lamp, Hefner. The former German standard lamp. It burned amyl acetate and used a wick. It is also known as the Hefner-Alteneck lamp.

Lamp, Isotope. A vapour lamp containing vapour of a single isotope, and hence producing light of high spectral purity. The best known of such lamps are the mercury isotope lamp, employing ^{198}Hg; the cadmium isotope lamp, employing ^{112}Cd, ^{114}Cd or ^{116}Cd; and the krypton isotope lamp, employing ^{86}Kr, which has replaced the cadmium vapour lamp as a wavelength standard.

Lamp, Mercury Vapour. A discharge lamp containing mercury vapour. It a blue-green light, rich in ultraviolet and near infrared, the precise character of which depends on the pressure at which the mercury vapour is maintained.

Lamp, Michelson. A special form of cadmium vapour lamp used by Michelson in his investigations of the emitted spectrum, which led to the adoption of the red line of cadmium as a primary standard.

Lamp, Verson Harcourt. The former British standard lamp. It burned pentane and did not use a wick.

Lamy's, Theorem. For a particle in equilibrium under the action of three forces of magnitude A, B and C

$$A/\sin \alpha = B/\sin \beta = C/\sin \gamma$$

where α, β and γ are respectively the angles between the lines of action of the forces B and C, A and C and A and B.

Landau Damping. The damping of a space charge oscillation by a stream of particles moving at a speed slightly less than the phase speed of the associated wave.

Landau Fluctuations. The fluctuations in the observed rate of the energy loss of fast particles when this loss is measured by the ionization produced in "thin" detectors.

Lande Interval Rule. For sufficiently weak spin-orbit interaction, an atomic energy level splits into levels such that

the interval between successive ones is proportional to the larger of the total augular momentum values.

Lane Law. States that if a star contracts, its internal temperature rises.

Langmuir Effect. The ionization occurring when atoms of low Ionization Potential come into contact with hot metal of high Work Function. The effect can be used to produce intense ion beams of alkali metals.

Langmuir Law. States that, in a thermionic diode with space charge limited current, the anode current density is proportional to the 3/2 power of the anode-cathode voltage.

Laplace Azimuth Stations. Triangulation stations set up to control the measurement of azimuth on the surface of the Earth.

Laplace Equation. The partial differential equation :

$$\delta^2u/\delta x^2+\delta^2u/\delta y^2+\delta^2u/\delta z^2=0$$

It may also be written in the form $\nabla^2u=0$, where ∇^2 is called the Laplace operator. It was formulated by the French mathematician P. S. Laplace (1749-1827).

Laplace Operator. Laplace Equation (def. 1).

Laplacian

1. The Laplace operator.
2. In nuclear reactor theory : the negative of the geometrical buckling.

Laporte Selection Rule. For atomic spectra : states that for electric dipole radiation, terms for which the sum of the azimuthal quantum number of the individual electrons are even combine only with those terms for which the sum is odd, and *vice versa*.

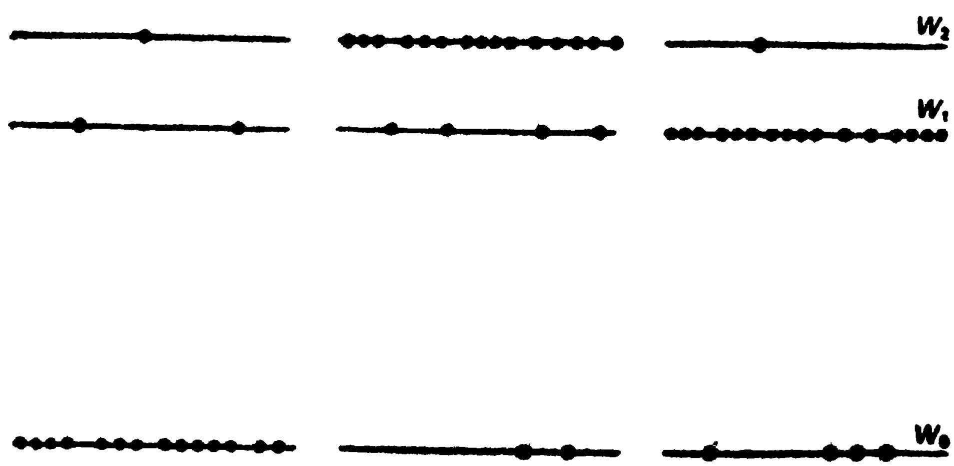
Larmor Precession Frequency. The frequency of the Larmor precession, also known as the gvromagnetic frequency.

Laser (light amplification by stimulated emission of radiation). A device able to produce a beam of radiation with unusual properties. Generally the beam is : coherent (the waves are in phase); monochromatic (the waves are of effectively the same wavelength); parallel; and intense (carrying a great deal of energy).

There are innumerable applications of such beams in communications, engineering, science, and medicine. Laser action is obtained in a volume of suitable material (solid, liquid, or gas) into which energy is passed at a high rate.

The input energy excites the active particles to a higher energy state W_2 from which they return to a comparatively stable state W_1 above the ground state, W_0. They accumulate there, forming a population inversion. Passing photons of energy (W_1-W_0) stimulate decay to the ground state. The photons emitted travel in phase with, and in the same direction as, those that stimulated their production.

In practice, reflecting surfaces are used at each end of the device--one totally reflecting and the other partially reflecting. The radiation is reflected backwards and for-



(a) normal condition (b) following excitation (c) population inversion

Laser

wards, building up an intense beam, which is emitted through the partially reflecting surface.

In solid lasers, such as the ruby laser, the population inversion is produced by an intense external light source. Generally it is pulsed. The wavelength is 694.3 nm. In gas lasers, a discharge is used. The carbon dioxide laser gives a wavelength of 10 5 μm. Helium-neon lasers produce a number of separate wavelengths, including 1.153 μm, 3.391 μm, and 632.8 μm. Gas lasers can produce continuous (rather than pulsed) beams.

Laser Cascade. A cascade of laser lines obtained in gases when, in a fluorescence spectrum, a given electron produces several photons related to each other by energy jumps between common energy levels.

Laser Diode. A semiconductor diode that emits coherent light when a voltage is applied to its terminals. It is usually constructed of gallium arsenide. The laser diode is the prime component of the gallium-arsenide injection laser that uses electric energy directly, pushing electrons to high energy states by injecting them across a PN junction. This type of laser is of special interest to home experimenters, because it is readily available and quite inexpensive, as compared to other types of lasers.

Laser, Infrared. A term sometimes used for a maser operating in the infrared region of the spectrum (up to about 750 μm).

Laser Protection. Protection against the harmful effects of laser beams. Of particular concern are the production of damage to the eye, sometimes leading to permanent blindness; to the skin, where serious burns may occur; and to other parts of the body, where tumours may be formed.

Lateral Chromatic Aberration. Chromatic Aberration.

Lateral Magnification. Another name for Magnification.

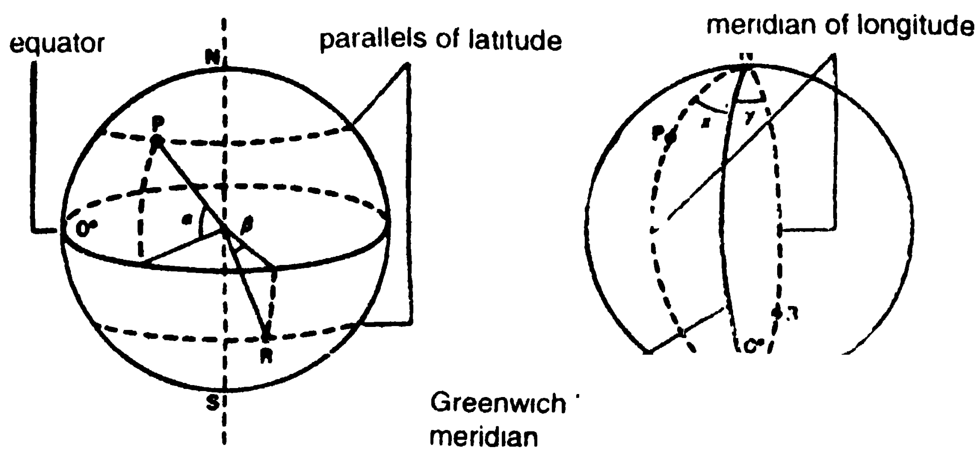
Lateral Velocity. The component of a celestial body's velocity that is at 90° to its line-of-sight velocity.

Latitude. The angle between the plane of the equator and the normal to the Earth at the point whose latitude is required.

Latitude and Longitude

1. (In geography) Imaginary lines on the earth's surface, enabling any point to be defined in terms of two angles subtended at its centre. Parallels of latitude are circles drawn round the earth parallel to the equator; their diameters diminish as they approach the poles. These parallels are specified by the angle subtended at the centre of the earth by the arc formed between a point on the parallel and the equator. All points on the equator therefore have a latitude of 0°, while the north pole has a latitude of 90° N and the south pole of 90°S. Parallels of latitude 1° apart are separated on the earth's surface by about 100 km.

   Meridians of longitude are half great circles passing through both poles; they cross parallels of latitude at right angles. In 1884 the meridian through Greenwich, near London, was selected as the prime meridian and designated as 0°. Other meridians are defined by the angle between the plane of the meridian and the plane of the prime meridian specifying whether it is E or W of the prime meridian. At the equator meridians 1° apart are separated by about 112 km.



The latitude of P is given by the angle a. In this case it would be α° N The latitude of R is β° S

The longitude of P is given by the angle x In this case it would be x° W N has a longitude of y° E.

Latitude and longitude

2. (In astronomy) The celestial latitude of a star, or other celestial body, is its angular distance north (taken as positive) or south (taken as negative) of the ecliptic measured along the great circle through the body and the poles of the ecliptic. The celestial longitude is the angular distance from the vernal equinox measured eastwards along the ecliptic to the intersection of the body's circle of longitude; it is measured in the same direction as the sun's apparent annual motion.

Latitude, Astronomical. Of a point on the Earth's surface : the angle between the axis of rotation of the Earth and the plane tangent to the geoid at the point of interest.

Latitude, Celestial : **Latitude, Ecliptic.** Of a celestial body : its latitude on the celestial sphere referred to the ecliptic as equator and to the corresponding poles.

Latitude, Galactic. Of a celestial body : its latitude on the celestial sphere referred to the galactic poles and galactic equator.

Latitude, Geocentric. Of a point on the Earth's surface : the angle between the equatorial plane and the radius of the Earth which passes through the point in question.

Latitude, Geodetic. Of a point on the Earth's surface; the angle between the axis of rotation of the Earth and the plane tangent to the spheroid at the point in question.

Latitude, Geographical : Latitude, Terrestrial. Of a point on the Earth's surface : the angle between the equatorial plane and the normal to the surface of the Earth at the point in question.

Latitude, Geomagnetic. Latitude defined in the same way as geographical latitude but with respect to the geomagnetic axis of the Earth.

Latitude, Photographic. The range of exposure permissible or the range of density usefully obtainable in a photographic emulsion. A measure of this is the quantity D_s/γ, where

D_s is the saturation density produced by development of all the grains and γ is the slope of the straight line portion of the characteristic curve.

Latitude, Variation of. A variation of a few tenths of a second of arc about a mean value, arising from the fact that the Earth's axis of rotation is not quite fixed with respect to the crust.

Lattice

1. A regular array of points in two and three dimensions. When atoms, molecules or ions are situated at such points, a Crystal System results.
2. A regular pattern of fissile material and moderator in some Nuclear Reactor Types.

Lattice Constants. A specification of the size and shape of the Unit Cell of a crystal structure by the lengths of the cell edges and the sizes of their angles of intersection.

Lattice Constants : Lattice Dimensions : Lattice Parameters. Terms loosely used to denote unit cell dimensions. They specify the size and shape of the unit cell of a crystal structure in terms of the cell edges and their angles of intersection.

Lattice Energy. A measure of the stability of a crystal lattice, given by the energy that would be released per mole if atoms, ions, or molecules of the crystal were brought together from infinite distances apart to form the lattice.

Lattice Rotation. In the plastic deformation of a metal : the progressive change of orientation of a crystallite, relative to the direction of the applied force.

Latus Rectum. Ellipse; hyperbola; parabola.

Laue Diagram. The diffraction pattern which results when a beam of X rays or of some other kinds of radiation or particles is passed through a thin crystal on to a photographic plate behind the crystal. The type of crystal and its structure can be deduced from the pattern.

Laue Equations. A set of three equations governing the diffraction of X-rays which must be satisfied to permit reinforcement of the contributions scattered from atoms at successive equivalent points of a crystal along each of its coordinate axes. This set of equations represents an alternative to the Bragg law as a method of expressing the conditions for selective reflection. The Laue equations also hold for the diffraction of electrons, neutrons, etc.

Laue Method : Laue Photography. The examination of the diffracted beams which are produced for any arbitrary setting of a stationary crystal from a beam of "white" radiation (*i.e.* a beam containing a wide continuous range of wavelengths). Each set of crystal planes selects the wavelength that will satisfy the Laue equations and produces a diffraction "spot" on a photographic film.

Launch Vehicle. A rocket used to launch a satellite, space-probe, space station, etc. Multistage rockets are usually used, the empty tanks and engine of the first two stages being jettisoned before the desired orbit is reached. The launch window is the time interval during which the vehicle must be launched to achieve the orbit.

Laurent Series. A generalization of the Taylor series whibh makes it possible to develop a function of the complex variable about a singular point.

Laval Nozzle. A nozzle which first converges and then diverges. When used to produce a steady stream of gas at a supersonic speed the flow is subsonic in the converging part, supersonic in the diverging part and sonic at the throat (whose the area of cross-section is a minimum).

Laves Phases Intermetallic phases the structures of which are associated with relations between the atomic size ratios, as was first pointed out by Laves.

Law of Flotation. Flotation, law of.

Law of Magnetic Poles (law of magnetism). The rule describing the forces between nearby poles—like poles repel each other; unlike poles attract each other.

Law of Moments. Moment.

Laws of Conservation. Conservation of mass and energy, constant energy (law of), constant (linear) momentum (law of), constant mass (law of), constant angular momentum (law of).

Laws of Electromagnetic Induction. Electromagnetic Induction.

Laws of Friction. Friction.

Laws of Reflection. Reflection, laws of.

Laws of Refraction. Refraction, laws of.

Laws of Thermodynamics. Thermodynamics.

Lawrencium. Symbol Lr. A radioactive metallic transuranic element belonging to the actinoids; a.n. 103; mass number of only known isotope 257 (half-life 8 seconds). The element was identified by A. Ghiorso and associates in 1961. The alternative name unniltrium has been proposed.

Layer Lattice. A type of crystal lattice in which the atoms in the layers are strongly bound but the bonding between layers is weak. Graphite for example has a layer lattice.

Layer Line. One of a series of horizontal lines obtained on a cylindrical film when a single crystal is rotated in a beam of monochromatic X-rays about a crystallographic axis which coincides with the axis of the cylinder.

LCD. An acronym for liquid crystal display, a display technique that uses segments of a liquid crystal solution in a sandwich of glass plates. The light-reflecting properties of the solution are controlled by an electric field.

LCM. Abbrev. for Least Common Multiple.

LCR Circuit. Alternating-current circuit.

LD 50. Short for median lethal dose.

Lead

(1) An electrical conductor.

(2) The angle or interval of time by which a particular phase of one periodically varying quantity is in advance of a similar phase in another such quantity.

There may for example be a lead between an alternating current and the electromotive force producing it, and *vice versa*. Compare Lag.

Lead-acid Accumulator. A type of electrical accumulator used in vehicle batteries. It has two sets of plates; spongy lead plates connected in series to the negative terminal and lead oxide plates connected to the positive terminal. The material of the electrodes is held in a hard leadalloy grid. The plates are interleafed. The electrolyte is dilute sulphuric acid. The e.m.f. when fully charged is about 2.2 V. This falls to a steady 2 V when current is drawn. As the accumulator begins to run down, the e.m.f. falls further. During discharge the electrolyte becomes more dilute and its relative density falls. To recharge the accumulator, charge is passed through it in the opposite direction to the direction of current supply. This reverses the cell reactions, and increases the relative density of the electrolyte (c. 1.25 for a fully charged accumulator).

The electrolyte contains hydrogen ions (H^+) and sulphate ions (SO_4^{2-}). During dischaige, H^+ ions react with the lead (IV) oxide to give lead (II) oxide and wate

$$PbO_2+2H^++2e^-\rightarrow PbO+H_2O$$

This reaction takes electrons from the plate, causing the positite charge. There is a further reaction to yield soft lead sulphate :

$$PbO+SO_4^{2-}+2H^+\rightarrow PbSO_4+H_2O+2e^-$$

Electrons are released to the electrode, producing the negative charge.

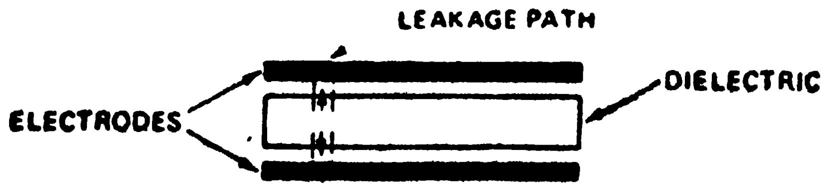
During charging the reactions are revesed :

$$PbSO_4+2e^-\rightarrow Pb+SO_4^{2-}$$

$$PbSO_4+2H_2O\rightarrow PbO_2+4H^++SO_4^{2-}+2'e^-$$

Leakage Resistance. The ohmic value of the path between two electrodes that are insulated from each other. Fig. shows a basic capacitor with both elements separated

from each other by a dielectric. In this case, the leakage resistance would be the total ohmic value measured from one point on one plate to a similar point on the other. The leakage resistance would be the same as the dielectric resistance. If the two electrodes were separated by air,



the leakage resistance would be measured through this medium. In almost every case, leakage resistance is extremely high and is measured in megohms or gigohms.

Least Action, Principle of. States that a conservative dynamical system in passing from one configuration to another does so in such a way that the action of the system remains stationary. This stationary value could be a maximum but is usually found to be a minimum.

Least Common Multiple. The smallest number that every number of a given set of numbers will divide into exactly. For example the lowest common multiple of 2, 3 and 5 is 30.

Least Constraint : Least Curvature. A general principle, comparable to the principle of least action, by means of which the path traced out by any dynamical system when acted upon by a given set of external forces may be determined. It states that, of all paths consistent with the constraints, the actual path is that for which the constraint or curvature is least.

Least Distance of Distinct Vision. The smallest distance of an object from the eye for clear vision of the object. For a young adult the average value is around 25 centimetre.

Least Energy Principle. For stable equilibrium the total potential energy of a system must be a minimum.

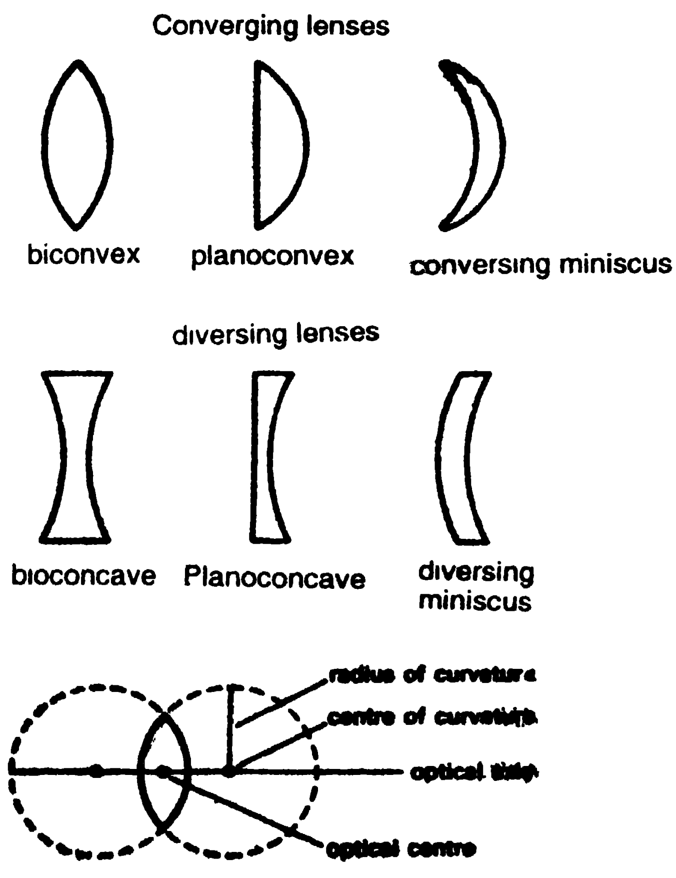
Least Squares Method. The determination of the most likely value from a set of observations by assuming that the sum

of the squares of the Deviation of each observed value from the most likely value is a minimum.

Least Time Principle. Fermats Principle of Least Time.

Least Work, Principle of. States that the deflections of individual parts of a structure subject to applied stresses are such that the load will be carried with a minimum storage of energy in the elastic members.

Lens. A curved, ground, and polished piece of glass, moulded plastic, or other transparent material used for the refraction of light. A converging lens is one that brings the rays of a parallel beam of light to a real principal focus. They include biconvex, planconvex, and converging meniscus lenses. Diverging lenses cause the rays of a parallel beam to diverge as if from a virtual principal focus; these include biconcave, planoconcave, and diverging meniscus lenses.



Lenses

The centre of curvature of a lens face is the centre of the sphere of which the surface of the lens is a part. The optical axis is the line joining the two centres of curvature of a lens or, in the case of a lens with one plane surface, the line through one centre of curvature that is normal to the plane surface. The optical centre of a lens is the point within a lens on the optical axis through which any rays entering the lens pass without deviation. The distance between the optical centre and the principal focus of a lens is called the focal length (f). The distance (v) between the lens and the image it forms is related to the distance (u) between the lens and the object by :

$$1/v+1/u=1/f,$$

provided that the real-is-positive convention is used. This takes distances to real objects, images, and foci as positive; those to virtual objects, images, and foci as negative. The equation does not always apply if the alternative New Cartesian convention.

Lens, Achromatic A lens designed to minimize chromatic aberration. In its simplest form it is composed of two lenses, one convergent and the other divergent, made of glasses having different dispersive powers, the ratio of their focal lengths being equal to the ratio of their dispersive powers.

Lens, Anamorphotic. A lens containing a cylindrical component, used in photography for producing distorted images.

Lens, Aplanatic. A lens in whose construction use is made of aplanatic points, whereby it possesses the property of giving a sharp image for rays making large angles with the axis.

Lens, Apochromatic. A compound lens that is sensible free from chromatic errors, from spherical aberration for two wavelengths, and from central coma for one wavelength.

Lens, Aspherical. A lens whose surface is made not quite spherical in order to reduce aberrations. The process

of treating a spherical surface (*e.g.* by polishing) so as to remove aberrations is known as figuring and a lens so treated is known as a figured lens.

Lens, Billet Split. A lens which has been cut across a diameter and the two halves separated slightly in a direction perpendicular to the cut and to the lens axis. Such a system produces two coherent images of, say, a slit, which can produce interference fringes. Such a lens is also known as a half lens.

Lens, Focal Length of. For a thin lens the focal length is the distance from the lens at which a parallel beam of light is brought to focus. It is given by $\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$, where f is the focal length, and u and v are the axial distances from the lens of the object and image respectively. For a lens made of material of refractive index n, the focal length is given by $\frac{1}{f}=(n-1)\left(\frac{1}{r_1}+\frac{1}{r_2}\right)$, where r_1 and r_2 are the radii of curvature of the surfaces. For a thick lens on such simple relationships exist.

Lens Formula. The formula

$$1/f=1/u+1/v$$

which on the sign convention real is positive and for rays close to and making small angles with the axis, applies to this spherical lenses; f is the focal length of the lens and u and v are respectively the object and image distances from the lens.

Lens, Fresnel. A compound stepped lens of annular refracting prism designed for lighthouses and intended to be free from spherical aberration. It has also been developed for use in signal lenses.

Lenticular. Shaped like or relating to a lens.

Lenz's Law. That which states that whenever the value of an electric current is changed in a circuit, it creates an electromotive force by virtue of the energy stored up in its magnetic field, which opposes the change.

Leptons. A class of elementary particles that do not participate in strong interactions; it includes the electron, muon, the massive tau lepton, the neutrinos, and their associated antiparticles. Leptons show no evidence of any internal structure. The lepton number is the total number of leptons minus antileptons in a system.

Lepton Number. The number of leptons minus the number of anti-leptons in a system. It is believed to be conserved in any conceivable process, *i.e.* only a lepton-anti-lepton pair may be created or annihilated.

Leslie's Cube. A cube-shaped can with the four sides painted different colours or given different finishes (polished, rough, etc.). It is filled with hot water and used in experiments on the effect of surface on emissivity.

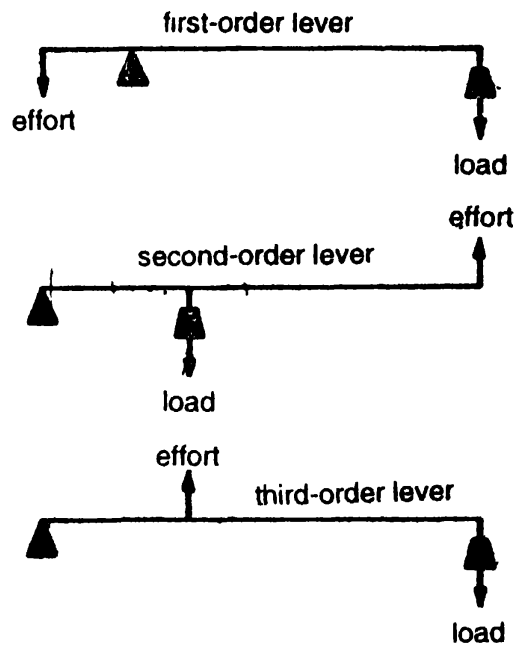
Let. Abbrev. for Linear Energy Transfer.

Level. An instrument used in surveying to determine heights. It usually consists of a telescope and attached spirit level mounted on a tripod. The level is set up between a point of known height and a point for which the height is required. Before use it is adjusted until the line of sight is exactly horizontal. Sightings are then made onto a graduated levelling staff at the two points. The difference in elevation between the two points can then be calculated from the readings taken at these points.

Levitation. The suspension of an object without visible support. Electromagnetic levitation is produced by generating eddy currents in an electric conductor by a time-varying magnetic field; it is the basis of a prototype cost-effective transport system.

Lever. A simple machine consisting of a rigid bar pivoted about a fulcrum. The mechanical advantage or force ratio of a lever (the ratio of load to effort) is equal to the ratio of the perpendicular distance of the line of action of the effort from the fulcrum to the perpendicular distance of the line of action of the load from the fulcrum. In a first-order lever the fulcrum comes between

load and effort. In a second-order lever the load comes between the fulcrum and the effort. In the third-order lever the effort comes between the fulcrum and the load.



Levers

Leyden Jar. A form of condenser generally used in making experiments on static electricity. It consists of a glass jar coated inside and out to a certain height with tinfoil, having a brass rod terminating in a knob passed through a wooden stopper, and connected to the inner coat by a loose chain.

LF. Abbrev. for low frequency.

Libration. The phenomenon that enables 59% of the moon's surface to be observed from earth over a 30-year period, in spite of its synchronous rotation. Physical libration arises from slight variations in the rotation of the moon on its axis, caused by minor distortions in its physical shape. Geometric librations are apparent oscillations arising from the fact that the moon is observed from slightly different directions at different times. The geometric libration in longitude results from the nonuniform orbital motion of the moon. The geometric libration in latitude arises because the moon's axis of rotation is not perpendicular to its orbital plane; it enables more of the lunar polar regions to be observed.

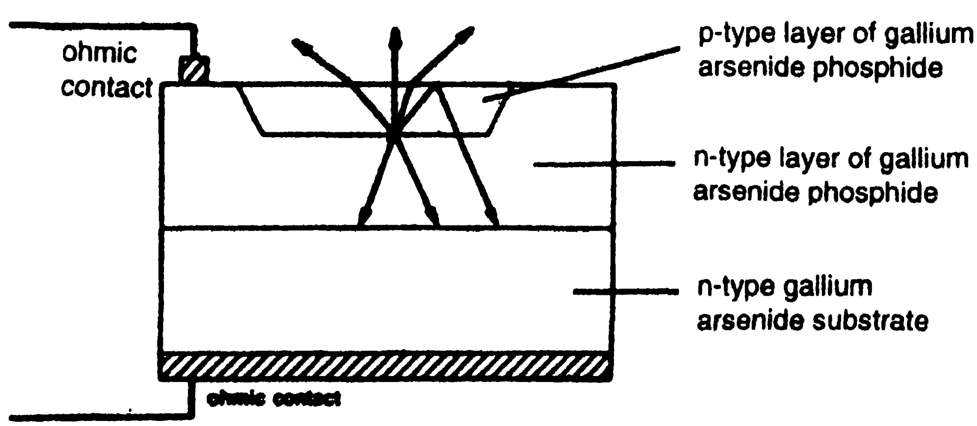
Lichtenberg Figure. The pattern of the discharge on the surface of a sheet of dielectric when the plate is subjected to a corona discharge by being placed between two appropriate high-voltage electrodes. The pattern exists only as a latent image until it is "developed", for example by dusting the surface with dielectric powder. Also, if the dielectric plate is a photographic plate or film this image may be developed photographically in the usual way.

Lift. On a body in a flowing fluid : the component of the force exerted by the fluid on the body at right angles to the direction of flow.

Light Bulb. Electric lighting.

Light Distribution Curve. A curve indicating the distribution of light emitted by a source. It may be in polar or cartesian coordinates and may show the luminous intensity in a horizontal or vertical plane, or show the variation with the angle of emission. A solid of light distribution is a surface such that the radius vector from origin to surface in any direction is proportional to the luminous intensity of the source in same direction.

Light-emitting Diode (LED). A rectifying semiconductor device that converts electrical energy into light or infrared radiation in the range 550 nm (green light) to 1300 nm (infrared radiation). The most commonly used LED emits red light and consists of gallium arsenide-phosphide on a gallium arsenide substrate, light being emitted at a



Light-emitting diode

p-n junction, when electrons and holes recombine (recombination process). LEDs are extensively used for displaying letters and numbers in digital instruments in which a self luminous display is required.

Light-gas Gun. For the study of aerodynamic ballistics, aerophysics, and impact : a gun employing a light propellant gas, such as helium or hydrogen, to reduce the mass of the propellant and permit the achievement of high speeds (over 8 km/s—the re-entry speed for an orbiting vehicle).

Light-gathering Power (light grasp). A measure of the ability of an optical telescope to collect light and thus discern fainter objects. It is proportional to the area of the telescope aperture, *i.e.* to the square of the diameter of the primary mirror or objective.

Light Guide. A single fibre or array of fibres in a Fibre Optics system.

Lighting Outlet. An outlet intended for the direct connection of a lampholder, a lighting fixture, or a pendant cord terminating in a lampholder.

Lightness. The property of a colour determined by the amount of light it reflects. Colours of the same hue but different lightness are known as shades.

Lighting Conductor. A sharply pointed metal rod attached to the top of a building and connected to the Earth's surface. A sharp point in the region of a charged cloud becomes strongly charged by Induction and so ionizes the air above it. A Alternatively the discharge may occur between two charged clouds or between oppositely charged layers of the same cloud : this is known as sheet lightning. The potential difference required to initiate a flash is about 10^8 volt. Generally there is a downward leader stroke, *i.e.* partial discharge, followed by an upward return stroke, the latter being much more luminous. The average current in a stroke is about 10.000 ampere but maximum values of around 20.000 ampere, associated with a

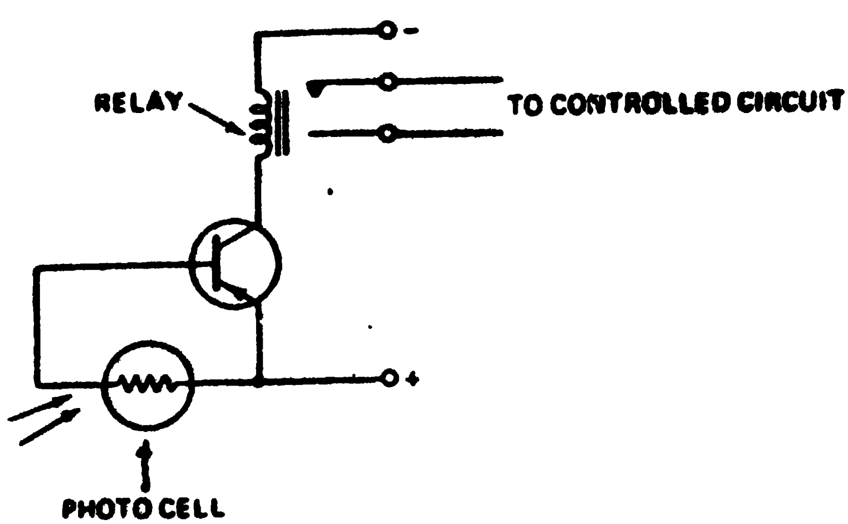
temperature of about 30 000 K, have been obtained A typical lightning flash consists of four or five strokes at about 40 millisecond part.

Ball lightning comprises a small slowly moving luminous ball of plasma which is said to vanish with a loud bang. This type of lightning is the rarest and least understood discharge between the cloud and the conductor therefore takes place more slowly and less violently than would a discharge between the cloud and Earth.

Lighting Rod. A device used to protect a structure from lightning. Lightning rods should be placed on upward projections such as chimneys, towers, and the like. On flat roofs, rods should be placed 50 ft on center, and on edges of flat roofs and ridges of pitched roofs, about 25 ft on center. The rods should project from 10 to 60 in, above flat roofs and ridges, and from 10 to 14 in, above upward projections.

Light Pen. A device connected to the Visual Display Unit of a computer. It is capable of sensing the information on the screen and can be used to impart information by, 'drawing' lines on the screen.

Light Relay. A photoelectric device that triggers a relay in accordance with fluctuations in the intensity of a light beam. These may be purely electronic in nature or electromechanical, depending on the individual circuit.



Often, light relays use an active or passive photoelectric device in the base circuit of a transistor, which is connected in series with an electromechanical relay. When light strikes the photocell, the transistor is driven to saturation and conducts current through the relay coil, causing it to change states. Such a circuit is shown in Fig. using a photovoltaic cell.

Light-sensitivity Materials. Substances which absorb visible and ultraviolet photons with the production of excited electronic states or electron emission.

Light Stimulus Light of such a wavelength as to stimulate a visual phenomenon. A physical measure of the stimulus is provided by the energy, dominant wavelength and spectral purity of the light.

Light Wave. A stream of electromagnetic energy that falls into the light spectrum. This lies between 100 and 10,000 nm. Visible light (that which can be seen by the human eye) lies within a very narrow bandwidth of this spectrum at a frequency range of about 500 to 600 nm.

Limb. The edge or rim of a celestial body having a visible disk, particularly that of the Sun and Moon.

Limit Gauge. A gauge applied to mechanical components to verify that the component size lies between the permitted high and low limits.

Limiting Angle of Prism. The largest angle of a prism of given transparent material, at its refracting edge, for which an emergent ray can be obtained. Its value is about twice the Critical Angle for the prism material.

Limiting Friction: The friction force that just balances a moving force applied to a solid body resting on a solid surface when the body fails to move. If the moving force exceeds the limiting friction, the body will begin to move.

Limiting Magnitude. The faintest apparent magnitude that may be observed through a telescope and/or recorded

on a photographic plate or other device. It depends on the telescope aperture, on the sensitivity of the recording device, on atmospheric conditions, etc. Star catalogues usually list stars to a specific limiting magnitude.

Limit of Resolution. Another name for Resolving Power.

Linac. Linear accelerator.

Linde Process. A method of liquefying gases by compression followed by expansion through a nozzle. The temperature falls by the Joule-Kelvin effect. The cooled gas is used to reduce the temperature of the compressed gas. Eventually the temperature falls below the boiling point and the gas liquefies. The gas must start this process below its inversion temperature. Hydrogen can be liquefied by this method if it is first cooled below its inversion temperature using liquid air. Helium is cooled below its inversion temperature by using liquid hydrogen boiling under reduced pressure.

Lindemann Electrometer. A form of quadrant electrometer which is insensitive to changes in level and which employs a needle as vane, whose movement is observed through a microscope for measurement.

Lindemann Glass. A lithium-beryllium borate glass containing only elements of low atomic number and so having a low absorption coefficient for X-rays. It is used, in the form of capillary tubes, for holding powders in X-ray diffraction analysis and, like beryllium, for the windows of X-ray tubes.

Linear

1. Characterized by one dimension only.
2. Arranged in, involving or represented by a straight line.

Linear Absorption Coefficient. Lambert's laws.

Linear Accelerator. A straight-line accelerator for charged particles in which a number of electrodes are so arranged

that, when a potential difference is applied at the proper radio frequency, the particles passing through them receive successive increments of energy. In the travelling wave linear accelerator, the particles are accelerated by the electric component of a travelling wave field set up in a wave guide.

Linear Acoustics. Acoustics.

Linear Amplifier. An amplifier whose output is linearly proportional to its input. Linear amplifiers are used for audio reproduction and in high-frequency applications requiring a linear response. They are often used to boost the output of single-sideband transmitters and accept the modulated signal at their inputs and then output the equivalent at a much higher amplitude.

A linear amplifier may be operated class A or AB single-ended or B push-pull. Class A RF power amplifiers, due to their low efficiency, are primarily used in low-power applications. Class B power amplifiers provide greater power output with increased efficiency but require well-regulated bias supply voltages. Class AB amplifiers represent a compromise in power and efficiency between class A and class B. Linear amplifiers are used to increase levels of power or voltage in cases such as amplitude-modulated carriers or single-sideband signals.

Linear Attenuation Coefficient. Symbol μ. A coefficient given by

$$(d\Phi/dl)/\Phi$$

where $d\Phi/dl$ is the rate of change of energy flux Φ with distance l traversed by the flux. The flux changes on its journey through a medium because of absorption and scattering by the medium.

Linear Charge Density. Charge density.

Linear Energy Transfer (LET). The energy transferred per unit path length by a moving high-energy charged particle (such as an electron or a proton) to the atoms and molecules along its path. It is of particular importance when

the particles pass through living tissue as the LET modifies the effect of a specific dose of radiation. LET is proportional to the square of the charge on the particle and increases as the velocity of the particle decreases.

Linear Expansivity. Another name for coefficient of linear expansion.

Linearly-polarized Radiation : Plane-polarized Radiation. Electromagnetic radiation so polarized that the vibrations lie in one single plane, the plane of vibration. The electric vector lies in this plane, which is sometimes called the plane of polarization, although the term is also applied to the plane at right angles to this (*i.e.*, the plane containing the magnetic vector), which may lead to confusion.

Linear Momentum. Symbol p. A vector quantity given by the product of the mass of a particle and its velocity. The linear momentum of a body or particle system is the vector sum of the linear momenta of the individual members.

Linear Momentum, Conservation of. Constant (linear) momentum (law of).

Linear Motion with Constant Acceleration. Motion described by the four equations :

$$v=u+at$$

$$v^2=u^2+2ax$$

$$x=ut+at^2/2$$

$$x=(u+v)t/2$$

where u and v are the initial and final linear speeds, x is the distance travelled in time t and a is the magnitude of the constant linear acceleration; speeds and distances in the direction opposite to that of the acceleration are taken as negative.

Linear Motor. A form of induction motor in which the stator and armature are linear and parallel, rather than cylindrical and coaxial. In some experimental trains the magnetic

force between the primary winding in the vehicle and the secondary winding on the ground support the vehicle on an air cushion thus eliminating track friction. However, because of the high cost of the installation and the low efficiency the device has not yet found commercial application.

Linear Programming. Refers to the problem of optimizing a linear function subject to linear constraints, as in operational research. For example, that of finding the non-negative values of $x_1, x_2, \ldots, x_i, \ldots, x_n$ for which $\sum_{i=1}^{n} a_i x_i$ is a maximum, subject to m linear constraints.

Linear Relationship. A relationship between two variables that can be represented by a straight line plot.

Linear Scale. A scale with equally spaced intervals of equal value.

Line Broadening. The production of broadened spectral lines by various effects. The natural width of a spectral line is determined by quantum mechanical uncertainty. Other factors can, however, produce extra line width, including doppler broadening, pressure broadening, and the Zeeman effect. Considerations of the line profile can give information about the physical conditions of celestial objects.

Line Defect. Defect.

Line Frequency. Of a television system : the number of lines scanned per second by the cathode-ray beam. It is a product of the number of lines in the picture and the number of times per second that the picture is scanned.

Lines of Force. Imaginary lines drawn to represent a force field. They show the direction of the field at each point; their closeness represents the field strength (the closer the lines, the greater the strength). In the case of magnetism, a line of force shows the path a free N-pole would take in the field.

Lines of force are a useful convention for showing fields; in magnetic fields they are the original basis of magnetic flux. They have, however, no real existence.

Line of Magnetic Induction. One of a series of lines which are thought of as passing from a magnetized body into the air at a north pole, entering the body again at the south pole, and returning through the body to the north pole to form a closed loop. This concept forms the basis of several definitions in the field of magnetism.

Line-of-sight Velocity (Radial velocity). The component of a celestial body's velocity along the line of sight of the observer. It is usually given in relation to the sun to avoid complications arising from the earth's orbital motion. Line-of-sight velocity is normally calculated from the Doppler effect on the body's spectrum, a redshift indicating a receding body (taken as a positive velocity) and a blueshift indicating an approaching body (taken as negative).

Line Printer. A device which prints the output of a computer a whole line at a time rather than printing individual characters. Line printer speeds up to 50 lines a second are obtainable.

Line Profile. The plot of radiation intensity against wavelength or frequency for a spectral line.

Lines of Force. Imaginary lines in a field of force that enable the direction and strength of the field to be visualized. They are used primarily in electric and magnetic fields; in electric fields they are sometimes called tubes of force, to express their characteristic of being perpendicular to a conducting surface. The tangent to a line of force at any point gives the direction of the field at that point and the number of lines per unit area perpendicular to the force represents the intensity of the field.

Line Spectrum. A spectrum consisting of discrete lines (spectral lines) resulting from radiation emitted or absorbed at definite wavelengths. Line spectra are produced by atoms or ionized atoms when transitions occur between their energy levels as a result of emission or absorption of photons. The Fraunhofer lines of the sun are an example of an absorption line spectrum.

Line Squall. A squall advancing on a wide front, caused by the replacement of a warmer by a colder body of air. It may extend for some hundreds of miles and its passage is marked by a rapid change in wind direction, a rapid rise in barometric pressure, a rapid fall in temperature, and violent changes in weather.

Line Voltage. The voltage between two line conductors of a polyphase a.c. system.

Line Width. The width of a spectral line in wavelength terms. The usual measure is the half-width of the line.

Linkage. The amount of magnetic flux embraced by an electric circuit.

Linkage Mechanism. A restricted form of mechanism for the transmission of motion. It consists of a series of rigid members joined together with constraints so that motion can be both amplified and redirected.

Liquation. The separation of mixtures of solids by heating to a temperature at which lower-melting components liquefy.

Liquefaction. A change of state to a liquid. The term is often used for the conversion of gases to their liquid state.

Liquefaction of Gases. The conversion of a gaseous substance into a liquid. This is usually achieved by one of four methods or by a combination of two of them :

1. By vapour compression, provided that the substance is below its critical temperature;
2. By refrigeration at constant pressure, typically by cooling it with a colder fluid in a countercurrent heat exchanger;
3. By making it perform work adiabatically against the atmosphere in a reversible cycle;
4. By the Joule-Thomson effect.

Large quantities of liquefied gases are now used commercially, especially liquefied petroleum gas and liquefied natural gas.

Liquefied Petroleum Gas (LPG). Various petroleum gases, principally propane and butane, stored as a liquid under pressure. It is used as an engine fuel and has the advantage of causing very little cylinder-head deposits.

Liquefied natural gas (LNG) is a similar product and consists mainly of methane. However, it cannot be liquefied simply by pressure as it has a low critical temperature of 190 K and must therefore be cooled to below this temperature before it will liquefy. Once liquefied it has to be stored in well-insulated containers. It provides a convenient form in which to ship natural gas in bulk from oil wells to users. It is also used as an engine fuel.

Liquid. A phase of matter intermediate between a gas and a solid and characterized by ease of flow and incompressibility. A liquid offers little resistance to shear stress and takes the shape of its container; unlike a gas it does not change its volume to fill the container. The intermolecular forces in liquids are larger than those in gases but smaller than those in solids. Diffraction studies show that liquids possess a short-range structural regularity which extends over several molecular diameters; these ordered bundles move around relative to each other. Theories of liquids are less well developed than those of solids and gases.

Liquid Air. A pale blue liquid resulting from the liquefaction of air. The blue colour is due to the liquid oxygen present.

Liquid Barometer. Barometer.

Liquid Crystals. Liquids which show double refraction and exhibit interference phenomena in polarized light. These liquid phases are known as mesomorphic phases and are described as smectic or nematic according as the molecules are arranged in sheets, or are more or less parallel without being so arranged. Liquid phases in which the molecules are spiral are known as cholesteric and may be regarded as a sub-group of the nematic group of phases.

Liquid-crystal Display. A digital display unit used in watches, calculators, etc. It provides a source of clearly displayed

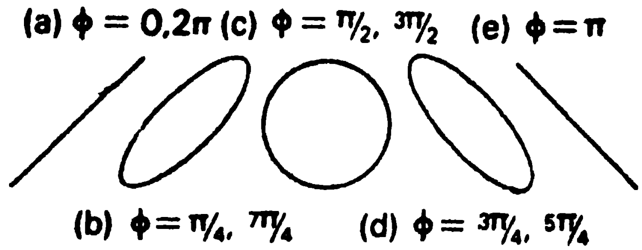
digits for a very low power consumption. In the display unit a thin film of liquid crystal is sandwiched between two transparent electrodes (glass with a thin metal or oxide coating). In the commonly used field-effect display, twisted nematic crystals are used. The nematic liquid crystal cell is placed between two crossed polarizers. Polarized light entering the cell follows the twist of the nematic liquid crystal, is rotated through 90°, and can therefore pass through the second polarizer. When an electric field is applied the molecular alignment in the liquid crystal is altered, the polarization of the entering light is unchanged, and no light is therefore transmitted. In these circumstances, a mirror placed behind the second polarizer will cause the display to appear black. One of the electrodes, shaped in the form of a digit, will then provide a black digit when the voltage is applied.

Liquid Degeneracy. The process by which a liquid, cooled below a certain temperature, loses its entropy of liquid disorder without going into the solid state.

Liquid-drop Model. A model of the atomic nucleus in which the nucleons are regarded as being analogous to the molecules in a liquid, the interactions between which maintain the droplet shape by surface tension. The model has been useful in the theory of nuclear fission.

Liquid Junction Potential : Diffusion Potential. The potential difference set up across the boundary between electrolytes of different composition. It arises from differences in the rates of diffusion of oppositely charged ions across the boundary.

Lissajous' Figures. Patterns obtained by combining two simple harmonic motions in different directions. They can be demonstrated with an oscilloscope, deflecting the spot with one oscillating signal along one axis and with another signal along the other axis. A variety of patterns are produced depending on the frequencies and phase differences.



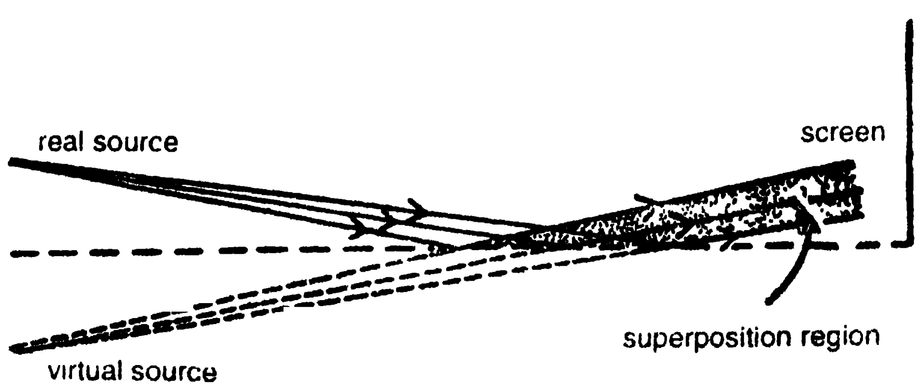
Lissajous figures

Litre Symbol l. A unit of volume in the metric system regarded as a special name for the cubic decimetre. It was formerly defined as the volume of 1 kilogram of pure water at 4°C at standard pressure, which is equivalent to 1 000 028 dm^3.

Littoral Current. The current along the seashore (or littoral zone). It causes intense marine abrasion.

Littrow Mirror. A plane mirror mounted nearly normal to the dispersed beam emerging from the prism in a prism spectrometer. For one particular wavelength the beam is reflected back upon itself, and the spectrum may be scanned by rotating the mirror instead of the prism. The spectrograph in which a Littrow mirrior is used together with an autocollimating device is known as a Littrow spectrograph.

Lloyd's Mirror. An optical arrangement for producing interference fringes. A slit is illuminated by monochromatic light and placed close to a plane mirror. Interference occurs between direct light from the slit and light reflected



Lloyd's mirror

from the mirror. It was first used by Humphery Lloyd (1880-81) in 1834.

Load

1. To put data into a register or storage.
2. To put a magnetic tape onto a tape drive, or to put cards into a card reader.
3. Name given to the amount of current being drawn from an electrical circuit.

For example, a 1200-W appliance connected to a 120-V circuit will load the circuit to an ampacity of 10-A or 1200-W. When a 15-A circuit is connected to a load of, say, 18-A, the circuit is said to be overloaded, or carrying more current than it was designed to carry.

Loaded Concrete. Concrete containing elements (such as iron or lead) with a high mass number; it is used in making the radiation shield around nuclear reactors.

Load Factor. The ratio of the average load to the maximum load over a certain period. The time may be either the normal number of operating hours per day or 24 h, as generally used by the power companies. The average load is equal to the kilowatt-hours used in the specified time, as measured by a watthour meter, divided by the number of hours. The maximum load is the highest load at one time, as measured by some form of maximum-demand or curve-drawing watthour meter.

Lodestone. The first known magnet, consisting of the mineral magnetite, Fe_3O_4.

Lobe. That portion of the overall radiation pattern of an aerial which is contained within a region bounded by directions of minimum intensity. The term is sometimes used to describe the radiation within the region.

Lobe Switching : Beam Switching. In radar : A method of determining the direction of a target by successive comparisions of the signals corresponding to two or more beam directions differing slightly from the target direction.

Local Group. The cluster of galaxies of which our own Galaxy is a member, It consists of some 25 galaxies. the most massive of which are the Galaxy and the Andromeda galaxy.

Local Oscillator. That stage in a receiver whose function is to produce a constant-amplitude sine wave of a frequency that differs from the desired station frequency by an amount equal to the intermediate frequency of the receiver. The operation of an oscillator may be either above or below the station frequency. In most broadcast band receivers, the oscillator is operated above the station frequency. In order to allow selection of any frequency within the range of the receiver, the turned circuit of the RF stage and the local oscillator are variable. By using a common shaft or ganged turning for the variable component of the tuned circuits. both circuits may be turned in such a manner as to maintain the difference between the local oscillator frequency and the incoming station frequency equal to the receiver intermediate frequency.

Locus. The curve traced by a point moving so as to satisfy a given condition. For example a circle is the locus of a point which moves so that its distance from a fixed point, the centre, is constant.

Lodestone. Another name for Magnetite.

Logarithmic. Denoting a relationship in which one variable is proportional to the Logarithm of another.

Logarithmic Decrement

1. For the decay of an oscillatory motion whose amplitude is decreasing exponentially : the decrease per swing in the natural logarithm of the amplitude.
2. For the elastic scattering of neutrons by nuclei of which the kinetic energy is negligible compared with that of the neutrons: the decrease per collision in the natural logarithm of the neutron energy.

Logical Operation. A term used in computer technology to signify a systematic self-consistent process used in the derivation of output information from input information.

Logic Circuit. A circuit designed to perform a particular logical function such as 'and', 'either...or', 'neither...nor'. Normally the circuits are binary logic circuits, *i.e.* they operate between two distinct voltage levels; such circuits are extensively used in computers and are usually formed from an Integrated Circuit assembly. A collection of logic circuits is known as logic network.

Logic Network. Logic circuit.

Log-periodic Antenna. A type of directional antenna that uses geometric iteration in order to achieve its wideband properties. The ratio of element length to element spacing remains constant due to the fact that the radiating element and the spacing between elements have dimensions that logarithmically increase from one end of the array to the other.

Longitude. The angular distance between the Earth's meridian at the point under consideration and the standard meridian, which is a great circle passing through the poles and Greenwich and whose longitude is assigned the value 0°.

Longitudinal Chromatic Aberration. Chromatic Aberration.

Longitudinal Wave. A wave motion in which the vibrations in the medium are in the same direction as the direction of energy transfer. Sound waves are an example of longitudinal waves. Compare transverse wave.

Long Sight. Another name for Hypermetropia.

Long-sightedness. Hypermetropia.

Loran. An acronym for long-range navigation, a system that provides a means of obtaining accurate navigational fixes from pulsed radio signals radiated by shore-based transmitters. Depending on the mode of Loran operation and the time of day or night, fixes are possible at distances up to 3000 nautical mi from the transmitting stations. A

Loran set aboard a ship or airborne is a receiving set and indicator that displays the pulses from Loran transmitting stations on shore.

Lorentz Contraction. A hypothesis put forward by Fitzgerald to account for the null result of the Michelson-Morley experiment which states that a body moving with velocity v is contracted in the direction of motion by the factor $\sqrt{(1-v^2/c^2)}$, where c is the speed of light. It is also known as the Lorentz-Fitzgerald contraction and the Fitzgerald-Lorentz contraction.

Lorentz Factor (Crystal Analysis). A factor which occurs in expressions for the intensity of reflection of X-rays or neutrons by crystal planes. It takes account of the effect on the intensity of the orientation of a crystal plane or the length of time (*e.g.* during the rotation of a single crystal) that the plane is in a reflecting position.

Lorentz-Fitzgerald Contraction. A reduction in the length of a body moving with a velocity v relative to an observer, as compared with the length of an identical object at rest relative to the observer. The object is supposed to contract by a factor $\sqrt{(1-v^2/c^2)}$, c being the speed of light. The contraction was postulated to account for the negative result of the Michelson-Morley experiment in classical terms. The idea behind it was that the electromagnetic forces holding atoms together modified by motion through the ether. The idea was made superfluous (along with the concept of the ether) by the theory of relativity, which supplied an alternative explanation of the Michelson-Morley experiment.

Lorentz Force. An aspect of the motor effect: the force on a charge Q, moving at velocity v across a magnetic field B.

$$f = BQv \sin \theta$$

θ is the angle between v and B.

Lorentz Invariant. A physical quantity f (r, t) in relativity theory which remains unaltered under a Lorentz transformation.

Lorentz-lorenz Formula. A formula relating the refractive index, n, and the density, ϱ, of a gas. For a given wavelength and state of aggregation it may be written as $\frac{n^2-1}{n^2+2}=\varrho\times\text{constant}$. For small changes in n it leads to the Gladestone-Dale law. It can also be applied to the variation of dielectric constant with density, when it leads to the Clausius-Mosotti equation.

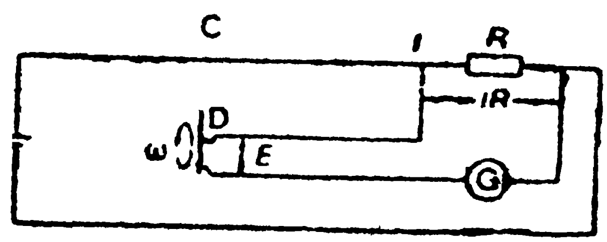
Lorentz Transformation. A set of equations used in the special theory of relativity to transform the coordinates of an event (x, y, z, t) measured in one inertial frame of reference to the coordinates of the same event (x′, y′, z′, t′) measured in another frame moving relative to the first at constant velocity v :

$$x=(x'+vt')/\beta$$
$$y=y'$$
$$z=z'$$
$$t=(t'+x'v/c^2)/\beta$$

β is the factor $\sqrt{(1-v^2/c^2)}$ and c is the speed of light. When v is very much less than c, these equations reduce to those used in classical mechanics.

Lorentz Unit. A unit of frequency in terms of which Zeeman splitting may be expressed. It is equal to $eH/4\pi mc^2$, where e/m is the charge-to-mass ratio of the electron, H is the magnetic field strength and the speed of light in a vacuum.

Lorenz Method for Resistance. An absolute method of determining resistance; the apparatus used is shown in Fig.



Absolute method of resistance measurement

Disc D is rotated at constant angular speed ω inside coil C and so on electromotive force E is produced as indicated. For zero deflection of galvanometer G, E must balance the potential drop across resistance R.

Thus

$$4\pi nIr^2\omega \times 10^{-7}/2 = IR$$

where I is the current through the coil, r its radius and n its number of turns. Hence

$$R = 2\pi nr^2\omega \times 10^{-7}$$

Lorenz Number : Lorenz Constant. The ratio of the thermal conductivity of a metal to the product of electrical conductivity and absolute temperature. It is approximately constant for many metal.

Loschmidt's Constant (Loschmidt number). The number of particles per unit volume of an ideal gas at STP. It has the value 2.68719×10^{25} m^{-3} and was first worked out by Joseph Loschmidt (1821-95).

Loschmidt's Number. Symbol L. The number of molecules in one cubic centimetre of an Ideal Gas at standard temperature and pressure. Its value is

$$2.68719 \times 10^{19}$$

Loss Angle. In a dielectric subjected to alternating electric stress; the angle by which the angle of lead of the current over the voltage is less than 90°.

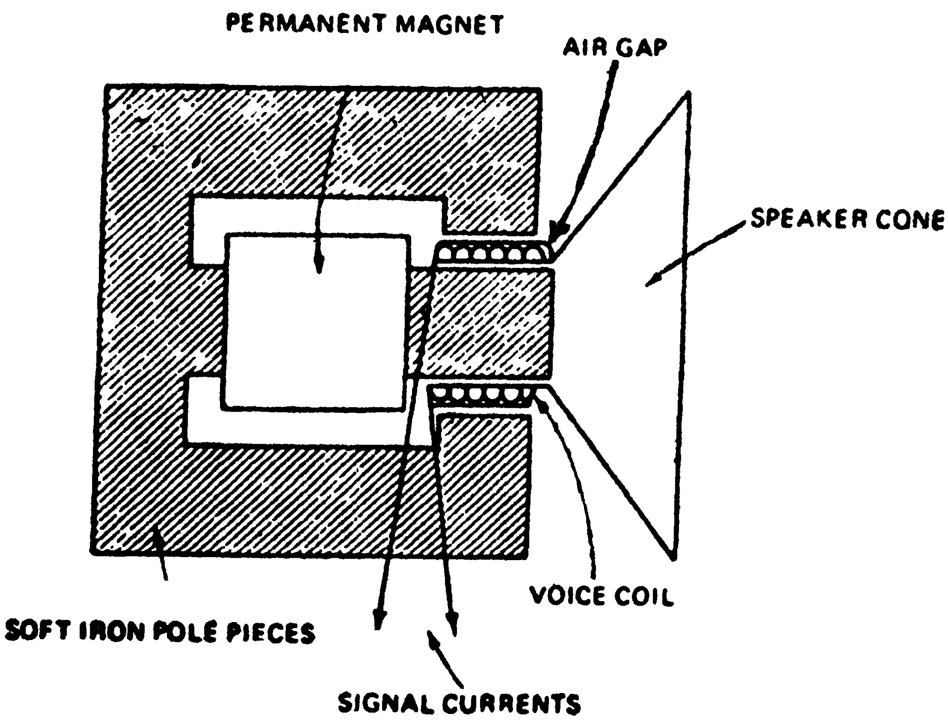
Lo Surdo Tube. A discharge tube with an extended cathode dark space used for observing the Stark effect in spectral lines emitted from that space.

Loudness. The sensation that a sound produces in a listener corresponding to its intensity (*i.e.* the energy flow per unit area). For a given frequency, the greater the intensity, the greater the loudness. Loudness also depends on the frequency of the sound.

Loudspeaker. An audio transducer that outputs acoustical energy from an electrical source. The purpose of audio reproduction devices such as loudspeakers and headphones

is to convert electrical audio signals to sound power. Fig. shows a diagram of a loudspeaker called a permanent magnet speaker. This speaker consists of a permanent magnet that is mounted on soft-iron pole pieces, a voice coil that will act as an electromagnet, and a loundspeaker cone that is connected to the voice coil.

The audio signal has been previously amplified (in terms of both voltage and power) and is applied to the voice coil. The vice coil is mounted on the center portion of the soft-iron pole pieces in an air gap so that it is mechanically free to move. It is also connected to the loudspeaker cone. As it moves, the conc will move as well.



When audio currents flow through the voice coil, the coil is moved back and forth proportionally to the applied ac current. As the cone (diaphragm) is attached to the voice coil, the coil is moved back and forth proportionally to the applied ac current As the cone (diaphragm) is attached to the voice coil, it also moves accordance with the signal currents and in so doing, periodically compresses and rarefies the air and thus produces sound waves.

Most speakers of this type receive their input by means of transformer coupling. This is necessary because of the normally low impedance of the voice coil. Standard impedance values for such speakers are 4.8,16 and 23Ω. Other impedance values may be obtained but these are the most common

While permanent magnet speakers perform reasonably well in the audio range, they nevertheless have inherent limitations.When the speaker is constructed, only a limited number of turns may be built into the voice coil. Therefore, it has a fixed inductance. At low frequencies, the inductive reactance of the voice coil will be relatively low, and large audio currents will flow. This provides a strong magnetic field around the voice coil and a strong interaction with the field of the permanent magnet. Low-frequency response is therefore excellent.

At mid-band frequencies. the inductive reactance has increased; and less current can flow in the voice coil. This produces less magnetic field and less interaction. Mid-band response, however, is still acceptable in a properly designed speaker.

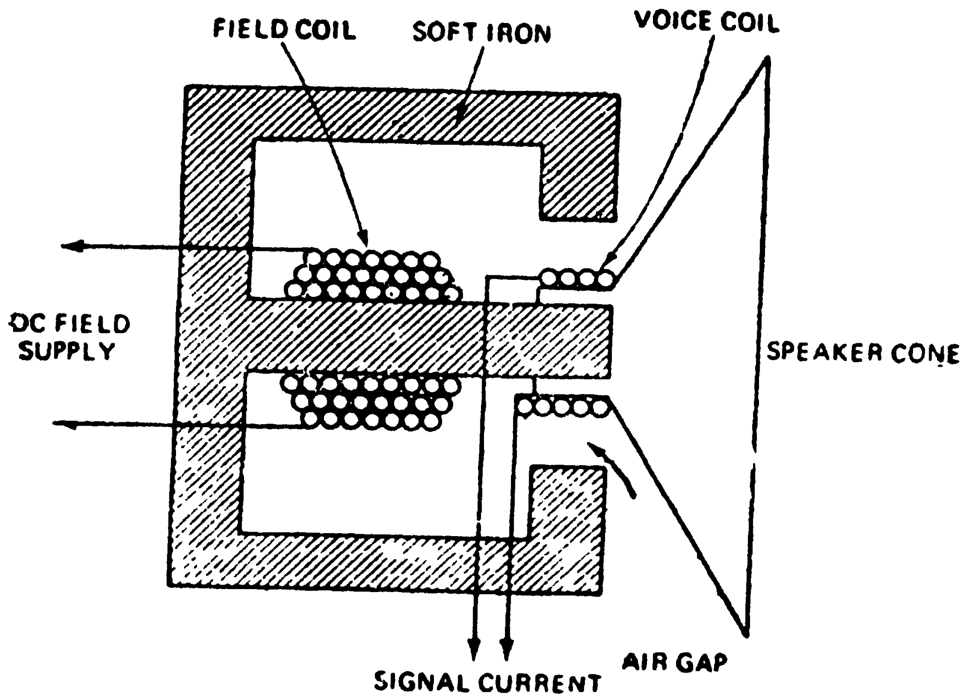
At high audio frequencies, inductive reactance is quite high, and very little current flows in the voice coil. This result in a greatly reduced voice coil field and very little interaction with the permanent magnet field. Also, at high frequencies, the interwinding capacities of the voice coil tend to shunt some of the high audio frequencies and further reduce the response.

The frequency response of most permanent magnet speakers will fall off at the higher audio frequehcies. This problem is normally overcome either by the prccurement of an expensive, specially designed speaker, or through the use of two speakers, on of which is designed to operate well at the higher audio frequencies.

As shown in Fig. an electromagnet may be used in place of the permanent magnet to form an electromagnetic

dynamic speaker. However, in this instance, sufficient dc power must be available to energize the field, electromagnet. The operation is otherwise much the same as that of the permanent megnet type.

Fig. shows a diagram of representative headphones as used in conjunction with this type of equipment. The device consists of a permanent magnet and two small electromagnets, through which the signal currents pass.



Electromagnetic speaker.

soft-iron diaphragm is used to convert the electrical effects of the device into sound power. When no signal current are present the permanent magnet exerts a steady pull on the soft-sron diaphragm. Signal current flowing through the coils mounted on the soft-iron pole pieces develops a magnetomotive force that either add to or subtracts from the field of the permanent magnet. The diaphragm thus moves in or out according to the resultant field. Sound waves are then reproduced that have an amplitude and frequency (within the mechanical capability of the reproducer) similar to the amplitude and frequency of the signal currents.

As compared to the permanent magnet speaker, standard headphones are considered to be high-impedance devices. Headphone electromagnets are normally wound of small wire with many turns providing the larger impedance. Because of the physically small size and inflexibilty of the metal diaphragm, the headphone oftten give poor response to the lower audio frequencies. In the voice range of audio, however, most headphones are adequate reproducers.

Love Wave. In an elastic medium : a wave which propagates along a stratum which is bounded on each side by a medium which has elastic properties which differ from those of the stratum. The particles of the medium are displaced in a direction parallel to that of the stratum.

Lovibond Tintometer. A colorimeter in which the colour is expressed in terms of standardized red, yellow and blue blue filters.

Low Frequency (LF). A radio frequency in the range 30—300 kilohertz; *i.e.*, having a wavelength in the range 1—10 kilometre.

Low Tension (L.T.) Low voltage.

LS Coupling. Coupling.

LSI. An acronym for large-scale integration, the combining of electrical components and circuits into a piece of solid-state material to produce subsystems containing 100 or more gates. The hand-held calculator was one of the first devices to employ large-scale integration. The introduction of such sophisticated circuits changed the field of digital electronics extensively.

Much more information can be placed on a single silicon chip without significant increase in its size. The cost of making such chips has not risen much because manufacturers have improved ways complex intergrated circuits are made. Also, because there are so many gates per chip, the cost per gate has been drastically reduced.

L.T. Low tension (voltage).

Lubrication. The process of introducing a substance between solid surfaces in relative motion in order to reduce friction, wear, overheating and rusting. Oils and greases of various types are widely used but at high temperatures graphite is more suitable. Air bearings are being increasingly used but involve continuous pumping of the air to the bearings.

Luder Bands : Strectcher Strains. Surface markings observed on mild steel and certain non-ferrous metals when strained beyond the elastic limit.

Lumen Symbol : lm The SI unit of luminous flux, equal to the luminous flux emitted by a point source of one cendela in a solid angle of one steradian, 1 lm=1cd sr.

Luminaire. A term now adopted internationally to denote lighting fittings.

Luminance. Spmbol L. The product of the leminous intensity per unit area of a surface viewed from a particular direction and the secant of the angle θ between the surface and that direction. Thus

$$L_v = \sec\theta \, dI/dA$$

where I is the luminous intensity and A the area of the surface. The unit is candela per square metre.

Luminaire A complete lighting unit that includes the lamp, sockets, and equipment for controlling light, such as reflectors and diffusers. On electric discharge lighting, the luminaire also includes a ballast. The common term used for luminaire is lighting fixture, or in some cases, simple fixture.

Luminance. Intensity in a given direction divided by projected area, as intercepted by the air. It is subjective intensity and ranges from very dim to very bright. Luminance is expressed as candelas per square inch in a certain direction. Candelas per square inch may be put into more convenient form by multiplying by 452, giving luminance

in footlamberts. Another way of looking at luminance is in relation to illumination and the reflection factor. For a nonspecular surface

Luminance=Illumination × Reflection factor

or

$$L=E\times R$$

where E equals footcandles, R equals reflection factor, and I, equals footlamberts.

To illustrate, if E=100 fc and R=50%, then L−100×0.50=50 fL.

Luminescence. The emission of radiation from a substance in which the particles have absorbed energy and gone into excited states. They then return to lower energy states with the emission of electromagnetic radiation. If the luminescence persists after the source of excitation is removed it is called phosphorescence; if not, it is called fluorescence.

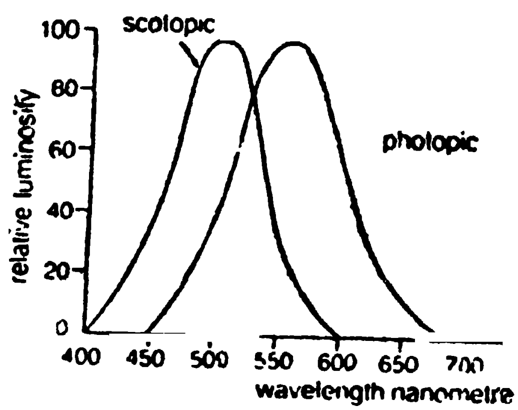
The excitation of the particles may occur by a variety of mechanisms Absorption of other electromagnetic radiation gives photoluminescence. If the original excited states are produced by bombardment with electrons the phenomenon is electroluminescence. Chemiluminescence is luminescence produced by chemical reactions. Bioluminescence occurs in natural systems, *e.g.*, glow worms and fireflies. Radioluminescence occurs in radioactive materials by friction is called triboluminescence.

Luminosity

1. Luminous intensity in a particular direction brightness of an image.
2. The brightness of a star defined as the total energy radiated in unit time. It is related to the surface area (A) and the effective temperature (*te*; the temperature of a black body having the same radius as the

star and radiating the same amount of energy unit area in second) by a form of Stefan's law, *i e.,*
where σ is the Stefan contant and L is the luminosity.

Luminosity Curves Ptots of variation with wavelength of the response of the eye to an equal energy spectrum. The curve at low levels of illumination, *i e.* the Scotopic Vision curve, differs from that at high levels of illumination, *i e.,* from the Photopic Vision curve, as shown in fig. The maxima of the curves are displaced from one another by about 0.5×10^{-7} metre. Although much great intensities are needed for photopic than for scotopic vision, the curves shown have been adjusted to the same maximum height.



Luminosity curves for equal energy spectrum

A Flicker Photometer is used to obtain the photopic curve. A test patch is illuminated alternately with a fixed intensity of light at the wavelength of the maximum and a variable intensity of another wavelength. This intensity is adjusted until all sensation of flicker disappears, *i e.,* until the two lights appear equally bright. The reciprocal of this intensity is the relative luminosity for the wavelength used. The measurement is repeated for a series of wavelengths throughout the visible spectrum. For the scotopic curve, a threshold method is suitable : the energy at each wavelength for threshold visibility of the test patch is measured and the inverse of each of these readings plotted against wavelength.

Luminous Efficiency. Of a radiation : the quotient of the luminous flux by the corresponding radiant flux.

Luminous Emittance. Another name for Luminous Exitance.

Luminous Exitance. Symbol M_v. The luminous flux leaving a surface per unit area. It is measured in lumen per square metre. Compare Radiant Exitance.

Luminous Flux. The rate of flow of luminous energy. It is the quantity characteristic of a radiant flux which expresses its capacity to produce visual sensation. The SI unit is the lumen, *i.e.*, the flux emitted within unit solid angle of one steradian by a point source having a uniform intensity of one cendela.

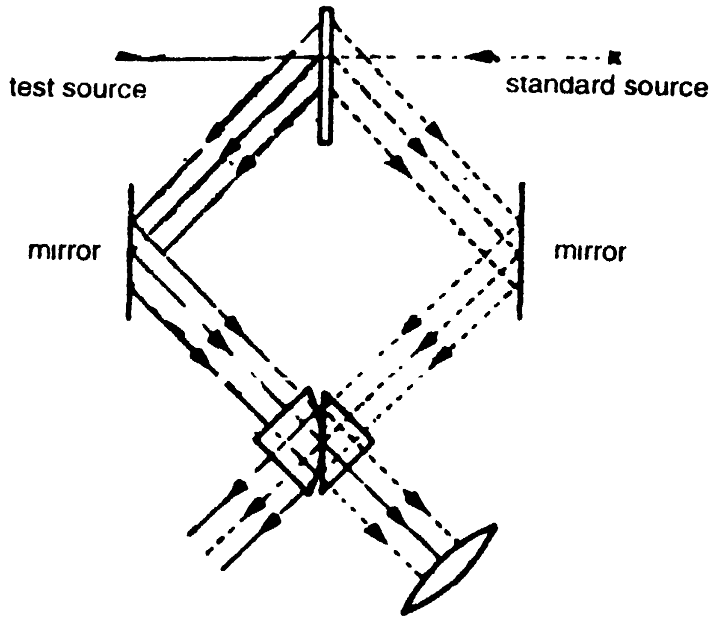
Luminous Intensity Symbol : I_v. The luminous flux from a point source per unit solid angle. The unit is the candela (cd).

Luminous Paint. Paint containing a Phosphor mixed with a small amount of radioactive material. Light is emitted as a result of bombardment of the phosphor by emissions from the radioactive material.

Lammer-brodhun Cupe. An optical device, employing two right-angled glass prisms, for assessing the brightness of a light source relative to that of a standard source. The prisms are so made and arranged that the light from one source passes to the eye through the centres of the prisms and is seen as a disk, while the light from the other source is peripherally reflected to the eye and is seen as a ring adjacent to and outside the disk. When the two sources have the same brightness the line of demarcation between the disk and the ring disappears.

Lammer-brodhun Photometer. A Photometer, illustrated in fig. The optical system used results in the illumination from the test source being seen as a spot surrounded by a region illuminated by the standard. The positions of the sources are adjusted until the field of view appears evenly illuminated. Measurement of these distances of

the sources from the screen enables their powers to be compared by applying the inverse square law in the usual way.



Lummer-braddun photometer

Lummer-gehrcke Plate. An interferometer consisting of a thick parallel-sided glass or quartz plate in which multiple reflections occur, giving rise to interference effects. The Resolving Power is about 10^6 and so the instrument is suitable for studies of the Hyperfine Structure of spectral lines.

Lumped Circuit. A circuit in which the energy storage and energy loss are essentially concentrated in relatively small regions possessing inductance, capacitance or resistance.

Lunar Day. The rotation period (27.322 earth days) of the moon, equal in length to the sidereal month. The moon is thus in synchronous rotation with the earth.

Lunar Eclipse. Eclipse.

Lusec. A unit of inleakage into a gas system, equal to litre of gas per second at 1 μm mercury pressure.

(**Note** : 1 mm mercury pressure has now been defined as 133·322 N/m^{-2} exactly).

Lunar Time. Time measured with respect to the Moon. The lunar month is the interval between successive new moons 12 lunar months comprise a lunar year, which is equivalent to 354.3671 mean solar days.

Lunar Year. A year of 12 synodic months, each of 29.5306 days, *i.e.* a year of 354.3672 days. A lunar calendar is based solely on the moon's motion; it has a year of 354 days with a leap year of 355 days and is composed of 12 months of 29 or 30 days. A luni-solar calendar is a lunar calendar that is brought into step with the solar or seasonal calendar by the intercalation (addition) of a 13th leap month.

Lunation. Another name for lunar month.

Lux. Symbol : *lx* The SI unit of illumination, equal to the illumination produced by a luminous flux of one lumen falling on a surface of one square metre. 1 $lx=1$ lm m^{-2}.

Lyman Series. A spectral series in the ultraviolet region of the hydrogen spectrum, with wavelengths λ given by

$$1/\lambda=R(1-1/m^2)$$

R is the Rydberg Constant and m is an integer greater than 1.

M

Mach Angle. The semi-angle of the cone which is the envelope, *i.e.* the wave front, of the spherical pressure waves generated by a body moving at supersonic speed through a medium. It is given by $\sin^{-1}(1/M)$ where M is the Mach Number.

Mach Cone The wave front of a Mach wave.

Machine. A device capable of making the performance of mechanical work easier, usually by overcoming a force of resistance (the load) at one point by the application of a more convenient force (the effort) at some other point. In physics, the six so-called simple machines are the lever, wedge, inclined plane, screw, pulley, and wheel and axle.

Machine Tool. A power-driven machine for changing the shape or size of a workpiece by the displacement or removal of material.

Mach Number. The ratio of the speed of a moving object (*e.g.* a high-speed aircraft) to the speed of sound in the air or other medium through which the object is travelling. An aircraft passes through the 'sound barrier' as the mach number exceeds one; at this speed the air resistance increases sharply.

Mach's Principle. The inertia of any particular piece of matter is attributable to the interaction between that piece of matter and the rest of the universe. A body in isolation would have zero intertia. This principle was stated by Ernst Mach in the 1870s and was made use of by Einstein in his general theory of relativity.

Mach Wave. The shock wave set up by an object moving with a Mach number greater than unity.

Maclaurin's Series. Taylor series.

Maclaurin Theorem. A special case of Taylor's theorem which states that, if f(x) and all of its derivatives remain finite at $x=0$, then

$$f(x)=f(0)+f'(0)x+f''(0)\frac{x^2}{2!}+\dots$$
$$+f^{(n-1)}(0)\frac{x^{n-1}}{(n-1)!}+R_n$$

where R_n is the remainder after n terms. When R_n converges as n increases the result is the Maclaurin series for f(x) at $x=0$.

Macroscopic

1. Sufficiently large to be seen without using a microscope.
2. Displaying properties associated with the statistical behaviour of large numbers of atoms or molecules.

Madelung Energy. The sum of the electrostatic interactions for an ionic crystal in the expression for the Coulomb energy of the crystal. The electrostatic energy per ion pair is $\alpha_M e^2/v_0$, where α_M is the Madelung constant, e the electronic charge, and v_0 the inter-ionic distance. This constant is a pure number, determined only by the crystal structure.

Magellanic Clouds. Two small galaxies situated close to the Milky Way that are only visible from the southern hemisphere. They were first recorded by Ferdinand Magellan (1480-1521) in 1519.

Magic Numbers. Numbers of neutrons or protons that occur at atomic nuclei to produce very stable structures. The magic numbers for both protons and neutrons are 2, 8, 14, 20, 50, and 82. For neutrons 126 and 184 are also magic numbers and for protons 114 is a magic number. The relationship between stability and magic numbers

led to a nuclear shell model in analogy to the electron shell model of the atom.

Magma. The molten material from which igneous rocks crystallize. At the Earth's surface it appears as volcanic lava.

Magnadur. A tradename for a ceramic material used to make permanent magnets. It consists of sintered iron oxide and barium oxide.

Magnalium. A tradename for an aluminium-based alloy of high reflectivity for light and ultraviolet radiation that contains 1—2% of copper and between 5% and 30% of magnesium. Strong and light, these alloys also sometimes contain other elements, such as tin, lead, and nickel.

Magnet. A device for producing a magnetic field. A magnet is either temporary or permanent : thus the magnetic field of an Electromagnet exists only while current flows; on the other hand a magnetized piece of ferromagnetic material has a permanent magnetic field and is therefore a permanent magnet.

Magnetic Amplifier. A device in which the non-linear properties of a ferromagnetic material are used to amplify a small signal into one of greater power. Magnetic amplifiers control the alternating current flowing through a circuit containing an inductance by controlled saturation of the inductance. They are analogous to dielectric amplifiers in which the non-linear properties of a ferroelectric material are used in the same way.

Magnetic Axis : Geomagnetic Axis. Of the Earth : the axis of the dipole whose field represents the major portion of the Earth's magnetic field. It makes an angle of about 12° with the axis of rotation of the Earth.

Magnetic Balance. A device for the direct determination of the force between magnetic poles. In a simple type a long bar magnet is balanced horizontally on a knife edge. Another pole is then placed above or below one of the magnet's

poles so that the latter is deflected downwards. From the position of a rider which can be moved along the bar magnet to restore the horizontal balance, the force between the poles can be calculated.

Magnetic Bay. A disturbance in which the horizontal intensity of the Earth's magnetic field deviates slightly from normal, but returns later to its undisturbed value, the deviation of the magnetic curve resembling the outline of a coastal bay.

Magnetic Bottle. A magnetic force field used to contain charged particles as in nuclear fusion experiments (where it contains the plasma). The plasma temperature may exceed 100 million degrees Celsius and any material container would vaporize instantly. The temperature is so high that all the electrons are stripped from the atoms and the matter consists entirely of charged particles, which can be restrained by a suitably arranged magnetic field.

Magnetic Bubbles. Cylindrical domains of reverse magnetization which occur in thin crystal platelets of certain materials, notably rare earth orthoferrites. These bubbles may be produced at will and are moveable under certain conditions. In principle they could form the basis of devices for logic, memory, switching and counting circuits

Magnetic Bubble Memory. A form of computer memory in which a small magnetized region of a substance is used to store information. Bubble memories consist of materials, such as magnetic garnets, that are easily magnetized in one direction but hard to magnetize in the perpendicular direction. A thin film of these materials deposited on a nonmagnetic substrate constitutes a bubble-memory chip. When a magnetic field is applied to such a chip, by placing it between two permanent magnets, cylindrical domains called magnetic bubbles) are formed. These bubbles constitute a magnetic region of one polarity surrounded by a magnetic region of the opposite polarity. Information is represented as the presence or absence of a bubble at a specified storage location and is retrieved by means of a rotating magnetic field. Typically a chip measures 15 mm^2,

or 25 mm^2 enclosed in two permanent magnets and two rotating field coils; each chip can store up to one million bits.

Magnetic Circuit. A device which includes either a permanent magnet or a current-carrying coil of wire which provides a well-defined path (or paths) for the magnetic flux. It is in some ways analogous to a simple electrical circuit.

Magnetic Compass. Compass.

Magnetic Conductance. Of a magnetic circuit : the reciprocal of the magnetic reluctance, *i.e.*, $\mu A/l$, where l is the length of the circuit, A its cross-sectional area, and μ the permeability.

Magnetic Constant. Symbol μ_0. The absolute Permeability of free space. It has the value

$$4\pi \times 10^{-7} \text{ henry per metre.}$$

Magnetic Cooling. A method for producing very low temperatures. Isothermal magnetization of a paramagnetic salt at low temperature followed by Adiabatic Demagnetization can produce a temperature as low as 10^{-3} K. If, at a temperature of about 10^{-2} K, isothermal magnetic alignment of the nuclear spins of a substance with nuclear magnetic moments is followed by adiabatic demagnetization, the production of a temperature as low as 10^{-6} K is feasible.

Magnetic Crack Detection. A technique for locating discontinuities on or near the surface of a ferromagnetic substance. The substance is painted with a dispersion of fine iron particles in oil and the distribution of magnetization investigated : irregularities indicate the sites of discontinuities since the iron particles congregate there.

Magnetic Crochet. A displacement of small amplitude in the continuous record of the horizontal component, declination or variation, or vertical component of the Earth's magnetic field.

Magnetic Cycle. A plot of the magnitude of magnetic induction against that of magnetic field strength.

Magnetic Data. Any data stored by the use of devices that utilize the magnetic properties of materials. Such data may be stored on magnetic tape, disc, or drum, or in magnetic core storage. In the case of a magnetic tape, bits of tiny invisible magnetized spots are stored as rows and columns that have been created in a thin film or iron oxide on the surface of a plastic tape. The writing and reading of bits signifying data is accomplished by usiug a tiny electromagnet (called a head) that the surface passes under.

Magnetic Dating. The dating of archaeological objects by comparing the direction of magnetization in ferrous objects in situ with the present direction of the geomagnetic field.

Magnetic Declination : Magnetic Variation At a point on the Earth's surface : the bearing of magnetic north, east or west of the celestial pole, *i.e.*, the angle between magnetic north and geographic north.

Magnetic Deviation. The angle between the magnetic north and the compass direction, the latter being affected by the presence of local ferromagnetic material, as on board ship. The deviation will, in general, change with the direction of the ship's head.

Magnetic Dip : Magnetic Inclination. At a point on the Earth's surface : the angle between the horizon and the direction of the Earth's magnetic field.

Magnetic Dipole. A pair of north-seeking and south-seeking magnetic poles a distance apart, as in a bar magnet. A loop carrying an electric current also acts as a magnetic dipole as do many atoms.

Magnetic Dipole Moment. The product of the pole strength of one of the two poles of a magnetic dipole and the separation of the poles. A small loop of wire of area A carrying a current I behaves as a magnetic dipole and has a magnetic moment IA, sometimes known as the electromagnetic moment.

Magnetic Disk. A smooth aluminium disk, usually 35 6 cm in diameter, both surfaces of which are coated with magnetic iron oxide. The disks are used as a recording medium in computers, up to ten such disks being mounted in a disk pack. Data is recorded in concentric tracks on both surfaces with up to 236 tracks per centimetre. The disks rotate at 3600 revolutions per minute, information being put onto the disk and removed from it by means of a record-playback head.

Magnetic Domains. Tiny regions of strong magnetism existing inside ostensibly unmagnetized ferromagnetic material.

Magnetic Double Refraction : Voigt Effect. The double refraction exhibited when light is passed through a vapour in a direction perpendicular to a strong magnetic field.

Magnetic Elements. The Earth's magnetism at any point is defined by three magnetic elements, which give the strength and direction of the field at that point. They are the horizontal component of the field and the angles of inclination and declination. The horizontal intensity can be measured by an Earth inductor, the inclination by an inclinometer, and the declination by a compass. In Britain the values are :

horizontal component, about 1.88×10^{-5} tesla
declination, about 9.8° West
inclination, about 66.7° North

The elements change from place to place and with time.

Magnetic Energy : Intrinsic Induction. Defined as B H, where B is the magnetic induction in a magnetic field H. It is also called ferric induction. The CGS unit is the gauss-oersted and the SI unit the tesla-ampere per metre (=40 π or about 125.6 gauss-oersted).

Magnetic Equator. A line on the Earth's surface joining all points of zero Dip. It is everywhere close to the equator.

Magnetic Field. A region in which a magnetic force can be observed; *i.e.*, a small magnet or a small loop of wire

carrying a current will experience a force. The strength and direction of a field can be represented by lines of force. The number of lines per unit cross-sectional area is a measure of magnetic field strength—the magnetic flux density B.

Magnetic Field Intensity. The quantity designated H and sometimes called magnetic intensity, which is directly related to the force exerted by a magnetic field. The unit used in measuring field intensity is the oersted, one oersted being equal to the strength necessary to exert a force of one dyne per unit magnetic pole. This relationship may be expressed mathematically as

$$H = \frac{f}{m}$$

where H equals field intensity in oersteds, f equals the force acting upon a magnetic pole in dynes, and m equals the strength of the magnetic pole in unit poles.

For a bar magnet or an electromagnet whose cross-sectional area is small compared to its length, field intensity is directly proportional to the magnetomotive force and inversely proportional to the length of the magnet. The formula then becomes

$$H = \frac{MMF}{cm} = \frac{1.257\ NI}{cm}$$

where H equals the field intensity in oersteds, MMF equals the magnetomotive force in gilberts, and cm equals the length in centimeters.

Magnetic Field Strength. Symbol H. A vector quantity equal to the Magnetic Induction divided by the absolute Permeability of the medium. The magnitude is measured in ampere per metre.

Magnetic Flux. Symbol Φ. A measure of quantity of magnetism, taking account of the strength and the extent of a magnetic field. The flux $d\Phi$ through an element of area dA perpendicular to B is given by $d\Phi = BdA$. The unit of magnetic flux is the weber.

Magnetic Flux Density (Magnetic induction). Symbol : B. A vector quantity that is a measure of the strength of a magnetic field in a particular direction at a particular point. It may be given in terms of the force, F, on a charge, q, moving in the magnetic field :

$$B = F/qv \sin\theta$$

where v is the velocity of the charge, which is moving at an angle θ to the direction of the field. Magnetic flux density is usually measured in teslas. The magnetic flux, symbol : Φ, is the surface integral of B, *i.e.*,

$$\Phi = \int B.dA = \int B \cos\alpha \, dA$$

where α is the angle between B and a line perpendicular to the surface. The magnetic flux density is thus the magnetic flux passing perpendicularly through unit area. Magnetic flux is measured in webers.

Magnetic Focusing. The use of shaped magnetic fields to focus beams of charged particles. Applications of the technique are found in cathode-ray tubes, accelerators, and electron microscopes.

Magnetic Force. The attractive or repulsive force exerted on a magnetic pole or a moving electric charge in a magnetic field.

Magnetic Hardness. Of a ferromagnetic material : a qualitative term expressing the size of the magnetic field required to produce saturation. The greater this field the harder the material.

Magnetic Hysteresis. In a ferromagnetic material in a magnetic field whose strength is varied : the lagging behind of the magnetic flux in relation to the magnetic field. If the magnetic field strength is plotted against the magnetic flux density, for values of field strength between zero and some given value, and back again to zero, a closed loop is obtained, the hysteresis loop, the area of which represents the energy expended in taking the material through the cycle. This energy is known as the hysteresis loss, and appears as heat.

Magnetic Image. The magnetic analogue of the electrical image.

Magnetic Inclination. Another name for Dip.

Magnetic Induction

1. The magnetization of a substance by an external magnetic field. If a sample of magnetic material is placed near a strong magnet N- and S-poles are induced in it. The sample will then act as an induced magnet and be attracted to the other.
2. Magnetic flux density.

Magnetic Intensity : Magnetic Field Strength. At a point in a magnetic field : the magnitude of the force experienced by a unit pole situated at that point. The CGS unit, corresponding to a force of 1 dyne, is the oersted. The SI unit, corresponding to a force of 1 newton, is the ampere per metre, 1 oersted being equal to 79.6 A/m.

Magnetic Leakage Factor. The ratio of the total flux which must be produced in a magnetic circuit or system to the useful flux in the circuit or system.

Magnetic Lens. A lens for focusing an electron beam, which may depend either on coils (electromagnetic lens) or permanent magnets (magnetostatic lens).

Magnetic Meridian. An imaginary line on the Earth's surface joining the two magnetic poles, and passing through the observer's position. It is the line along which a compass comes to rest at that point. The angle between the magnetic and geographic meridians is the declination at that point, one of the three magnetic elements.

Magnetic Mirror. A device used to contain plasma in thermonuclear experimental devices. It consists of a region of high magnetic field strength at the end of a containment tube. Ions entering the region reverse their motion and return to the plasma from which they have emerged.

Magnetic Moment (magnetic dipole moment). Symbol : m. A measure of the strength of a magnet or current-carrying

coil. It relates to the turning effect (moment) on it when in a given field. It is defined as the torque T observed in a unit field at 90° to the magnetic axis :

$$m = T/B$$

The units are ampere metres-squared (A m^2). For a coil with N turns and area A carrying a current I :

$$m = NIA$$

In this case m is often called the electromagnetic moment of the coil.

Magnetic Monopole A hypothetical magnetic entity consisting of an isolated elementary north or south pole. It has been postulated as a source of a magnetic field by analogy with the way in which an electrically charged particle produces an electric field. Numerous ingenious experiments have been designed to detect the monopole but so far none has produced an unequivocal result.

Magnetic Permeability. Permeability.

Magnetic Polarization. The quality of a material by which it possesses opposite or contrasting poles. In an atom, the electron has a negative charge, while the nucleus has a positive charge that is carried by the protons. The basic law of electric charges states that like charges repel and unlike charges attract. The positive charge of the nucleus of an atom attracts the electrons. However, the electrons are able to maintain their orbital paths because of their speed and energy. Since the forces of the atoms keep the electrical charges in balance, the atom remains stable and neutral.

Electrons orbiting about an atom, however, can determine the charge of that atom. Atoms that have either lost or gained outside electrons (known as valence electrons) can be negative or positive in charge, depending on the number of electrons involved in the transfer. They are then known as ions.

When two bodies, whether they be atoms or larger units of matter, have unlike charges, an electric stress is

created between the two bodies if they are placed close to each other, and they are said to repel. Oppositely charged bodies attract and tend to combine and neutralize.

The practical unit of measurement of electrical charge is the coulomb. The difference between charges or potentials is measured by the volt.

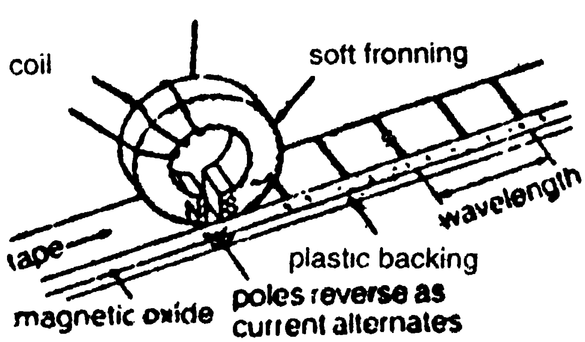
Magnetic Pole. A region near either end of a permanent magnet. Lines of force of the magnet's field converge on one pole and diverge from the other. A freely suspended magnet comes to rest in the direction of the Earth's magnetic field with its north-seeking pole pointing north and its south-seeking pole pointing south. Unlike magnetic poles attract each other and like ones repel each other. The force obeys the Inverse Square Law of variation with distance, just as does the force between electric charges.

Magnetic Pole Strength. Pole strength.

Magnetic Potential

1. At a point : the work done in bringing a unit north pole from infinity to that point.
2. In a magnetic circuit : the magnetomotive force.

Magnetic Recording. The process of recording sound on Magnetic Tape and then reproducing the sound from the tape. The principle of the tape recorder is illustrated in Fig The Tape moves at constant speed past a very narrow air gap in a ring of soft iron, which is magnetized by the current from the recording amplifier passing through the coil around the ring. Magnetism is thus in-



Magnetic tape recording

duced on the tape as indicated, the polarity depending on the phase of the coil current and the strength on the current strength. In playback the magnetic tape is run past the same ring at the same speed as previously. The magnets on the tape cause induction of current in the coil surrounding the ring. This current is amplified and then fed to a loudspeaker thus reproducting the sound.

Magnetic Reluctance. Of a magnetic circuit: the analogue of electrical resistance. It is given by $l/A\mu$, where l is the length of the circuit, A its cross-sectional area, and μ the permeability. It is the reciprocal of the magnetic conductance.

Magnetic Resistance. Reluctance.

Magnetic Screening. The protection of a space from magnetic effects by surrounding it with a material of high relative Permeability.

Magnetic Resonance. The absorption of microwaves or ratio waves by atoms or nuclei respectively in the presence of a static magnetic field.

Magnetic Saturation. The condition, approached only as the temperature approaches absolute zero, in which all magnetic spins are aligned in the same direction. In practice magnetic saturation usually signifies the condition in which the intensity of magnetization no longer continues to increase with increasing field strength. This is sometimes referred to as technical saturation.

Magnetic Screening : Magnetic Shielding The screening from a magnetic field which exists at the interior of an enclosure of high permeability material (*e.g.* a hollow ferromagnetic cylinder). The lines of induction tend to be strongly refracted as they pass into this material, leaving a relatively field-free space within.

Magnetic Shell. A thin sheet of ferro-magnetic material magentized across its thickness. It can be regarded as an infinite number of small magnets.

Magnetic Storm. A disturbance of the Earth's magnetic field due to electrical disturbance resulting from sunspot activity.

Magnetic Structure. Of a crystalline material: the structure related to the magnetic unit cell, which is not the same as the chemical unit cell in antiferromagnetic and ferrimagnetic crystals, owing to the existence of antiparallel spins in chemically identical atoms. The magnetic structure may be studied very effectively by neutron diffraction.

Magnetic Susceptibility. The ratio of the magnetic dipole moment per unit volume to the magnetic field strength.

Magnetic Tape. A plastic tape which is coated with a layer of iron oxide and can be magnetized to record sound (Magnetic Recording). Another application is the recording of binary information, in the form of magnetized dots, for use in computers.

Magnetic Variation

1. Various changes with time of the magnetic elements at a point on the Earth's surface. Secular changes are slow continuous changes. Thus the angle of declination at London has changed from zero in 1659 to 8° in 1960; the inclination at the same place has changed from 74° in 1700 to 66° in 1960. Abrupt changes in the magnetic elements are due to magnetic storms, which are related to solar activity.
2. Note that variation is still widely used in navigation instead of declination.

Magnetic Variometer. Any instrument that indicates or monitors departures of a magnetic element from some arbitrary reference value.

Magnetic Viscosity. The existence of a delay in the charge of magnetic induction in a ferromagnetic material when the applied magnetic field undergoes a sudden change, which is considerably longer than is to be expected from the consideration of eddy currents alone.

Magnetic Well. An arrangement of magnetic fields for containing a plasma in experimental Fusion Reactors.

Magnetism. The study of the nature and cause of magnetic force fields, and how different substances are affected by them. Magnetic fields are produced by moving charge—on a large scale (as with a currrent in a coil, forming an electromagnet), or on the small scale of the moving charges in the atoms. It is generally assumed that the Earth's magnetism and that of other planets, stars, and galaxies have the same cause. Substances may be classified on the basis of how samples interact with fields. Different types of magnetic behaviour result from the type of atom. Diamagnetism, which is common to all substances, is due to the orbital motion of electrons. Paramagnetism is due to electron spin, and a property of materials containing unpaired electrons. Ferromagnetism, the strongest effect, also involes electron spin and the alignment of magnetic moments in domains. Antiferromagnetism and ferrimagnetism are rarer effects involving antiparallel alignment of spin magnetic moments.

Magnetite. A black magnetic mineral consisting of ferro-ferric oxide. Pieces of the mineral were the earliest magnets.

Magnetization. Symbol M. A vector defined as

$$B/\mu_0 - H$$

where B is the Magnetic Induction, μ_0 the Magnetic Constant and H the Magnetic Field Strength.

Magnetization by Rotation : Barnett Effect. The magnetization of an initially unmagnetized specimen by the rotation of the specimen in the absence of any external magnetic field. The discovery of the effect by Barnett, in 1914, was the first successful experiment in the field of gyromagnetic phenomena. The inverse effect, the slight rotation of a suspended iron cylinder when suddenly magnetized, was discovered at about the same time by Einstein and de Haas.

Magnetization Curves. Plots of the magnitude of Magnetization in a magnetic specimen agains tthe magnitude of Magnetic Field Strength of the magnetizing field. If the specimen was demagnetized at the beginning of the investigation, the curves are called normal curves.

Magnetizing Current. The component of the current in the primary of a transformer that magnetizes the core and produces the required magnetic field. The current legs the applied voltage by 90° but it is in phase with the alternating flux is generates. The magnetizing force that produces the actual magnetic strength is measured in ampere-turns. It is obtained by multiplying the magnetizing current and the number of turns in the windings. If the number of turns is constant, the flux changes depend directly on the changes in magnetizing current.

Magneto. An alternating-current generator used as a high-tension source in the ignition systems of petrol engines in which there are no batteries, *e.g.* in some tractor, marine, and aviation engines (in road vehicles the expense of a magneto is saved by using an induction coil and storage battery). Most modern magnetos consist of a permanentmagnet rotor revolving within a primary (low-voltage) winding around which a secondary winding is placed in which to induce the high voltage needed to produce the spark to across the points of the plugs. Magnetos are geared to the engine shaft, the speed depending on the number of poles of the magneto and the number of engine cylinders. A make-and-break device is incorporated in the primary winding; when the primary current stops the sudden change of magnetic flux within the secondary induces in it the required large e.m.f.

Magnetoacoustics. The study of the interaction between magnetic fields and ultrasonic waves. Such a study can yield information about the electronic structure of a metal since, under appropriate conditions, ultrasonic energy may be absorbed by conduction electrons and returned as thermal vibrations to the lattice.

Magnetobremsstrahlung. Synchrotron radiation.

Magnetocaloric Effect. The change of temperature of a sample as the external field changes. In particular, energy is stored in ferromagnetic domains; as these appear or disappear, energy is absorbed or released. One use of the effect is in adiabatic demagnetization for the production or very low temperatures (close to absolute zero).

Magnetochemistry. The branch of physical chemistry concerned with measuring and investigating the magnetic properties of compound. It is used particularly for studying transsition-metal complexes, many of which are paramagnetic because they have unpaired electrons. Measurement of the magnetic susceptibility allows the magnetic moment of the metal atom to be calculated, and this gives information about the bonding in the complex.

Magnetoelastic Effects. The effects of stress and strain upon the magnetic properties of a ferromagnetic material.

Magnetograph. An apparatus for recording fluctuations in the Earth's magnetic field. It commonly comprises three variometers, each of which responds to a different magnetic element and gives a continuous record (a magnetogram) of the magnitudes of these elements.

Magnetohydrodynamic Generation of Electricity. The generation of electricity by the movement of a stream of highly ionized gas across a magnetic field.

Magnetohydrodynamics. The study of the behaviour of electrically conducting fluids, *i.e.* an ionized gas, a plasma, or some other collection of charged particles, in a magnetic field. The collective motion of the particles gives rise to an electric field that interacts with the magnetic field and causes the fluid motion to alter. This coupling between hydrodynamic force and magnetic forces tends to make the fluid and the magnetic field lines move together.

Magnetohydrodynamic Waves. Material waves in an electrically conducting fluid in the presence of a magnetic field. They are of importance in plasma physics and astrophysics.

Magnetomechanical Ratio. Gyromagnetic ratio.

Magnetometer. An instrument for measuring the magnitude, and sometimes the direction, of a magnetic field. Absolute magnetometers measure the field without reference to a standard magnetic instrument. The most widely used are the vibration magnetometer, the deflection galvanometer, and the more modern nuclear magnetometer. The vibration instrument was devised by Gauss in 1832 and depends on the rate of oscillation of a small bar magnet suspended in a horizontal plane. The same magnet is then used as a fixed deflector to deflect a second similarly suspended magnet. The deflection galvanometer uses a Helmholtz coil system of known dimensions with a small magnet suspended at its centre. The deflected magnet comes to rest at a position controlled by the earth's magnetic field, the coil's magnetic field, and the angle through which the coil must be turned to keep the magnet and the coil in alignment. The sensitive nuclear magnetometers are based on measuring the audiofrequency voltage induced in a coil by the precessing protons in a sample of water. Various relative magnetometers are also in use, especially for measuring the earth's magnetic field and in calibrating other equipment.

Magnetomotive Force. The magnetic analogue of Electromotive Force. It is the line integral of $H \cos \theta ds$ round a closed path : H is the magnitude of the megnetic field strength and θ the angle it makes with the path element ds.

Magneton. A unit for measuring magnetic moments of nuclear, atomic, or molecular magnets. The Bohr magneton μ_B has the value of the classical magnetic moment of an electron, given by

$\mu_B = eh/4\pi m_e = 9.274 \times 10^{-24}$ A m^2, where e and m_e are the charge and mass of the electron and h is the Planck constant. The nuclear magneton, μ_N is obtained by replacing the mass of the electron by the mass of the proton and is therefore given by

$$\mu_N = P_B\, m_e/m_p = 5.05 \times 10^{-27} \text{ A m}^2.$$

Magneto-optical Effects. Changes of the optical behaviour of matter when the external field changes. Examples are the Faraday effect and the Kerr effect.

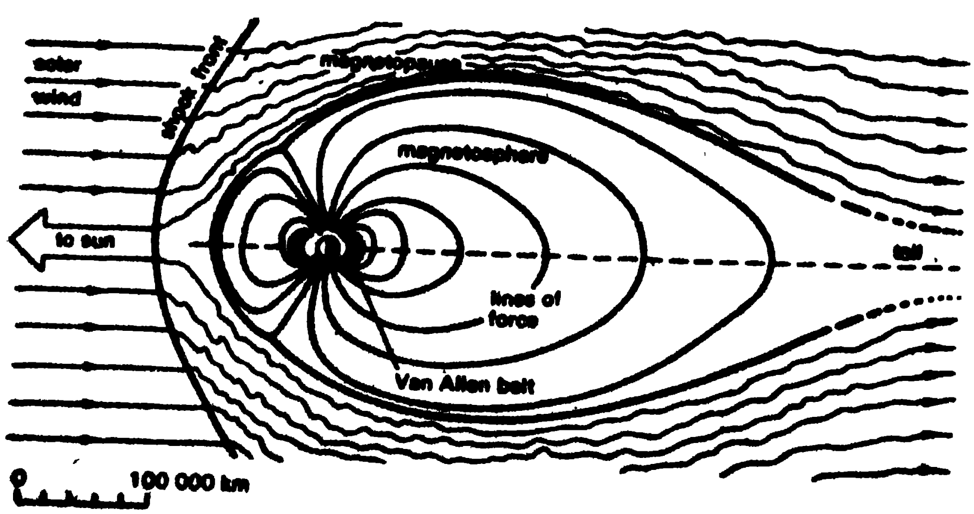
Magnetopause. The outer boundary of the Earth's magnetic field. It is approximately ten times the Earth's radius from the Earth's centre.

Magnetophotophoresis : Ehrenhaft Effect. The (usually) helical movement of fine dust particles in a gas along the lines of force of a magnetic field during their irradiation by light. It is one type of photophoresis.

Magnetoresistance. A change in the electrical resistivity of a substance due to the presence of an external magnetic field. It occurs in all metals but is most pronounced in ferromagnetic metals and their alloys.

Magnetoresistive Effect. The change of electrical resistance of a sample when the external field changes. The Hall effect is related to this.

Magnetosphere. A comet-shaped region surrounding the earth and other magnetic planets in which the charged particles of the solar wind are controlled by the planet's magnetic field rather than the sun's magnetic field. It extends for some 60,000 km on the side facing the sun but on the opposite side it extends to a much greater extent. The boundary of the magnetosphere is known as the magneto-



Magnetosphere and magnetopause

pause. The magnetosphere of the earth includes the Van Allen belts.

Magnetostatic Potential. Potential.

Magnetostatics. A development of magnetic theory analogous to electrostatics but based on magnetic poles rather than electric charges. Although free poles are not known, the results have some validity.

Magnetostriction. A change in the physical dimensions of a ferromagnetic substance due to a change in its magnetization.

Magnetostriction Effect. An effect that is similar to the piezoelectric effect found in crystal oscillators. Instead of using electric charges, however, it operates by the effect of a changing magnetic field. This compressional strain in effect squeezes the rod and makes it longer. When the field is removed, the rod returns to nearly its former length.

Similarly, when a rod located within a magnetic field changes its length, it also induces a change in the magnetic field, increasing or decreasing the field. When clamped in a fixed position at the middle, the bar will vibrate with a flezural motion similar to that of a tuning fork.

The metal composition of the bar determines its efficiency and effectiveness as a resonator. Temperature effects will cause changes in the bar length and thus the of operation; hence, for extreme stability, the alloy must frequency have a small temperature coefficient or temperature control must be used. Operation in this respect is similar to the operation of crystal oscillators.

Magnetostriction Oscillator. *The oscillation* of a rod of ferromagnetic material when placed in a coil carrying an alternating current of appropriate frequency. The effect may be used to provide a feedback system in an electronic oscillator, or for the production of ultrasonic waves.

Magnetothermal Analysis. The study of the magnetic behaviour of materials at various temperature to obtain information concerning their physical state. A well-known example is the study of the change of the saturation magnetization with temperature to determine the constitution of alloy systems. The curves employed are often referred to as σ—T curves.

Magnetron. A type of electron tube used for producing micro-waves. A steady magnetic field is applied from outside the tube. The electrons emitted from a hot cathode circle under the influence of the field and generate electromagnetic oscillations in resonant cavities in the surrounding anode.

Magnification. A measure of the extent to which an optical system enlarges of reduces an image. The linear magnification, M, is the ration of the image height to the object height. If this ratio is greater than one the system is enlarging, if it is less than one, it is reducing. The angular magnification, M or γ, is the ratio of the angles formed by the final image and the object (when viewed directly, in the most favourable position available) at the eye. This is also sometimes called the magnifying power of an optical system.

Magnifying Glass. A simple Microscope.

Magnifying Power (magnification). The angle subtended by the image of an object seen through a telescope, divided by the angle subtended by the same object seen without telescopic aid. Where the object is too small or too distant to be resolved, the magnifying power may be calculated from the ratio of the focal lengths of the objective (or primary mirror) and eyepiece, of from the aperture divided by the diameter of the exit pupil.

Magnitude. A measure of the relative brightness of a star or other celestial object. The apparent magnitude depends on the star's luminosity, its distance, and the absorption of light between the object and the earth. In 1856 the astronomer N. R. Pogson devised a scale in which a diffe-

rence of five magnitudes corresponds to a brightness ratio of 100 to 1. Two stars that differ by one magnitude therefore have a brightness ratio of $(100)^{0.2} : 1 = 2.512$, known as the Pogson ratio. This scale is now universally adopted. Apparent magnitudes are not a measure of luminosity, which is defined in terms of the absolute magnitude. This is the apparent magnitude of a body if it was situated at a standard distance of 100 parsecs.

Magnon. A quantum of magnetic energy analagous to the photon. It is of use in the consideration of excitation or de-excitation by neutrons of waves of magnetic spin.

Magnox. Any proprietary magnesium alloy used to encase fuel elements in some Nuclear Reactor Types. For example magnox A contains 0.8% aluminium and 0.01% beryllium.

Magnus Effect. The development of a circulation around a rotating cylinder which is held transversely in a stream of fluid, whereby a lift force is generated, equal to $\rho v \gamma$, where ρ is the density of the fluid, v the relative flow velocity, and γ the circulation. The effect formed the basis of the Flettner rotor, whereby the lift force on a rotating cylinder to be used to propel ships by the action of the wind on vertical rotating cylinders. It also accounts for the "slice" of a golf ball, and similar phenomena.

Main Sequence Star. Hertzsprung-Russell Diagram.

Mains Freqency. The frequency of the alternating-current electricity supply obtained from the grid. In Britain it is 50 hertz and in the USA 60 hertz.

Majority Carrier. The type of carrier-either electrons or holes-responsible for transporting more than half the current in a Semiconductor.

Make-and-break. An arrangement by which a circuit is alternately opened and closed; for instance by movement of an armature.

Malleability. The property of a material of being able to be beaten of rolled into a thin sheet without splitting.

Malus' Law. The intensity of light transmitted by a pair of Polarizers is proportional to $\cos^2\theta$ where θ is the angle between the axes of the polarizers.

Manganin. A copper alloy containing 13—18% of manganese and 1—4% of nickel. It has a high electrical resistance, which is relatively insensitive to temperature changes. It is therefore suitable for use as a resistance wire.

Mangin Mirror. A lens—mirror combination giving an intense parallel beam of light from a small source placed at the focus. It has been widely used in searchlights.

Manometer. A device for measuring pressure differences, usually by the difference in height of two liquid columns. The simplest type is the U-tube manometer, which consists of a glass tube bent into the shape of a U. If a pressure to be measured is fed to one side of the U-tube and the other is open to the atmosphere, the difference in level of the liquid in the two limbs gives a measure of the unknown pressure.

Manostat. A device for maintaining constant gas pressure in an enclosure, usually involving the use of a pressure-sensitive valve which admits gas to or exhausts gas from the enclosure in question.

Many-body Problem. The problem of solving the equations governing the interaction between a number of free particles whose initial positions and velocities are specified and which are subjected to known forces. For more than two bodies no rigorous solution can in general be found. Examples of many-body problems are planetary motion, many-electron systems and nucleon interactions.

Mark Space Ratio. The ratio of pulse duration to the time between pulses in a pulse waveform.

Mars The fourth planet from the sun and the nearest superior planet to the earth. It orbits the sun every 687 days at a distance that varies between 1.38 and 1.67 AU. Its reddish 6794 km diameter disc is most favourably placed for observation during oppositions that occur with Mars near

perihelion (Mars, oppositions). Mars rotates in 24h 37m 23s about an axis tilted by 24° to its orbital plane; these values help to make the Red Planet the most earthlike of all the other planets, even though it has only 28% of the earth's surface area. Mars has two small natural satellites : Phobos and Deimos.

Martensitic Transformation. A change of crystal stiucture of the type hccurring in the formation of martensite, *i e.*, one which is diffusionless, in which each atom tends t retain the same neighbours throughout the change. The new structure is thus obtained from the old by a process of deformation.

Marx Circuit. A circuit for the production of high-voltage pulses (*i.e.*, an impulse generator), in which capacitors can be charged in parallel and discharged in series.

Mascon A gravitational anomaly on the surface of moon result-ing from a concentration of mass below the lurar surface. They occur in circular lunar meria and were caused either by the mare basalt as it flooded the basins or by uplift of high-density mantle material when the basins were formed.

Maser. An amplifier or oscillator which operates on the same principles and shows the same characteristics as the Laser, but in the microwave region of the spectrum. The name is an acronym for microwave amplification by stimulted emission of radiation.

Mass. A measure of the quantity of matter in a body. The SI unit of mass is the kilogram. The astronomical unit of mass is the solar mass, *i e.*, 2×10^{30} kg. Mass is a property of matter that determines both the inertia of an object, *i.e.*, its resistance to any change in its motion or state of rest, and the gravitational field that it can produce. The former is called inertial mass, defined by Newtod's laws of motion, and the latter is gravitational mass. Inertial and gravitational mass have been found to be equivalent. This led to Einstein's principle of equivalence between inertial and gravitational forces.

Mass, Centre of. Centre of mass.

Mass Coefficient of Reactivity. In a nuclear chain-reacting medium : the partial derivative of reactivity with respect to the mass of a given substance in a specified location.

Mass Decrement. Of a nuclide : the difference between the atomic weight and the mass number.

Mass Defect

1. The difference between the rest mass of an atomic nucleus and the sum of the rest masses of its individual nucleons in the unbound state. It is thus the mass equivalent of the binding energy on the basis of the mass-energy equation.
2. (or mass decrement). The difference between the rest mass of a radioactive nucleus before decay and the total rest mass of the decay products.

Mass Doublets. In mass spectroscopy : doublets arising from ions or atoms with almost identical mass numbers.

Mass energy Relation. A relation governed by the equation

$$E = mc^2$$

where E is the energy produced by a change m in mass and c is the speed of light in free space. Thus matter can be created or destroyed with corresponding decrease or increase of the energy. The Conservation Law for mass and for energy considered individually is not strictly true, but the total mass-energy is conserved.

Mass Number. Symbol A. The number of nucleons in a nucleus.

Mass Spectrography : Mass Spectrometry. The identification of an atom, molecule or compound by virtue of its atomic or molecular weight. Positive ions of the material concerned are separated by the use of electric or magnetic fields, or both. In the mass spectrograph the ions are recorded on a photographic plate according to their mass/

charge ratios; and in the mass spectrometer it is usual to detect the particles electrically.

Mass Spectrometer. An instrument for producing ions in a gas and analysing them according to their charge/mass ratio. The earliest experiments by J. J. Thomson used a stream of positive ions from a discharge tube, which were deflected by parallel electric and magnetic fields at right angles to the beam. Each type of ion formed a parabolic trace on a photographic plate (a mass spectrograph).

In modern instruments, the ions are produced by ionizing the gas with electrons from at electron gun. The positive ions are accelerated out of this ion source into a high-vacuum region. Here, the stream of ions is deflected and focused by a combination of electric and magnetic fields, which can be varied so that different types of ion fall on a detector. In this way, the ions can be analysed according to their mass, giving a mass spectrum of the material. Mass spectrometers are used for accurate measurements of atomic weights, for analysis of isotope abundance, and for chemical identification of compounds and mixtures.

Mass Spectrum. Spectrum.

Mass Transfer Coefficient. Another term for diffusion coefficient or diffusivity.

Mass Transport By Waves. In a liquid containing progressive waves : the translation of the liquid in the direction in which the waves advance. The motion of translation decreases rapidly with increasing depth.

Matched Termination : Matched Load. For a waveguide : a termination producing no reflected wave at any transverse section of the wave guide.

Matching (Impedance Matching). Arranging electrical impedances so that maximum power is transferred from one device to another. This occurs when the input impedance of one device equals the output impedance of the other to which it is connected.

Material Particle. An atomic or sub-atomic particle which, although it exhibits wave properties, also possesses rest mass.

Matrix (Pl Matrices).

1. (In mathematics) A set of quantities in a rectangular array, used in certain mathematical operations. Unlike a determinant, a matrix does not have a quantitative value. The array is usually enclosed in round brackets.
2. (In geology) The fine-grained material of rock in which the coarser-grained material is embedded.

Matrix Mechanics. A form of quantum mechanics, initiated by Heisenberg, which sets out to work with directly observable quantities. It was developed prior to and independently of wave mechanics, but the matrix elements, as was shown by Schrodinger, may be defined in terms of normalized wave functions.

Matter. In general, anything that has 'substance'; a specialized form of energy with a finite rest mass, distinguished from electromagnetic radiation. The term is, perhaps, best avoided in physics.

Matthiessen Rule. An approximate rule stating that the electrical resistance of a metal is the sum of the reactance due to the scattering of electrons by the thermal vibration of the atoms (the ideal resistance) and that due to scattering by defects of various kinds (the residual resistance).

Maximum and Minimum Thermometer. A thermometer designed to record both the maximum and minimum temperatures that have occurred over a given time period. It usually consists of a graduated capillary tube at the base of which is a bulb containing ethanol. The capillary contains a thin thread of mercury with a steel index at each end. As the temperature rises the index is pushed up the tube, where it remains in position to show the maximum temperature reached; as the temperature falls the lower index is pushed down the tube and similarly remains in

position at the lowest temperature. The indexes are reset by means of a permanent magnet.

Maximum Density of Water. Water reaches its maximum density of 1000 kilogramme per cubic metre at a temperature of 4° C. The explanation is that ice crystals have a very open three-dimensional tetrahedral structure, which is not completely replaced by the closer-packed water molecular structure until the temperature reaches 4° C.

Maximum Permissible Dose. Dose.

Maxwell. A unit of magnetic flux in the c.g.s. system, equal to the flux through 1 square centimetre perpendicular to a magnetic field of 1 gauss. 1 maxwell is equal to 10^{-8} weber. It is named after James Clerk Maxwell (1831–79).

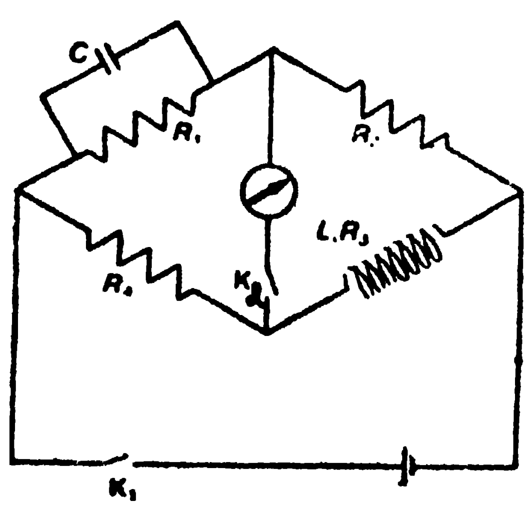
Maxwell-Boltzmann Distribution Law. The probability of finding among a total of N ideal gas molecules, each of mass m. molecules having speeds between c and c + & c is

$$(dN/N)/dc =$$

$$4\pi c^2(m/(2\pi kT)^{3/2} \exp(-mc^2/2kT)$$

where k is the Boltzmann constant and T the thermodynamic temperature.

Maxwell's Bridge. An electrical bridge circuit, shown in fig. used for measuring inductance. If keys K_1 and K_2 are



Maxwell's bridge

closed in that order, the ballistic galvanometer will not deflect provided

$$R_1R_3 = R_2R_4$$

If K_2 is closed followed by K_3, the condition

$$L = R_2R_4C$$

is necessary for zero galvanometer deflection. The Rs represent resistance values and L and C inductance and capacitance values respectively. By trial and error suitable resistance values are found to give the double balance ; L can then be calculated provided the value of C is known.

Maxwell Colour Triangle. A scheme for representing mixtures of colours, according to which the three primary colours, red blue and green, are placed at the corners of an equilateral triangle. On the sides facing these corners are placed the corresponding complementary colours, and any colour is represented by the coordinates of a point inside the triangle.

Maxwell's Demon. An imaginary being, conjured up by Maxwell, able to work a trap door in a partition in a vessel containing gas initially at uniform temperature. The trap door is operated so that only fast molecules enter one side and only slow ones the other side of the partition, thereby separating the gas into regions of higher and lower temperature.

Maxwell Distribution. A distribution of velocities among the particles of a gas. The curve of number of molecules against velocity has a characteristic shape that depends on temperature. The equation :

$$N = N_0 \exp \text{-} W/RT$$

gives the number of molecules N with energy greater than W. N_0 is the total number of molecules.

Maxwell Distribution Law : Maxwell—Boltzmann Distribution Law. For a perfect gas : a law giving the average number of molecules having speeds within well-defined

limits. The fraction of molecules of mass m having speeds between c and c + dc is given by

$$4\pi\left(\frac{m}{2\pi kt}\right)^{3/2} c^2 \exp\left(-\frac{mc^2}{2kt}\right),$$

where k is Boltzmann's constant and T the absolute temperature.

Maxwell's Equations. Four differential equations that describe the electric and magnetic fields at a point. From these equations James Clerk Maxwell deduced that the field vectors obey a wave equation and that light is propagated as electromagnetic waves. These equations form the basis of classical electrodynamics. They are :

$$\text{curl } H = \partial D/\partial t + j$$
$$\text{div } B = 0$$
$$\text{curl } E = -\partial B/\partial t$$
$$\text{div } D = \rho$$

where H is the magnetic field strength, D is the electric displacement, j is the current density, B is the magnetic flux density, E is the electric field strength, and ρ is the volume charge density.

Mean Density of Matter. Symbol : ρ_0. The factor that determines the dynamical behaviour of the universe, *i.e.*, whether it is open or closed. The density parameter, Ω_0, is a dimensionless quantity given by

$$\Omega_0 = 8\pi G\rho_0/(3H^{02})$$

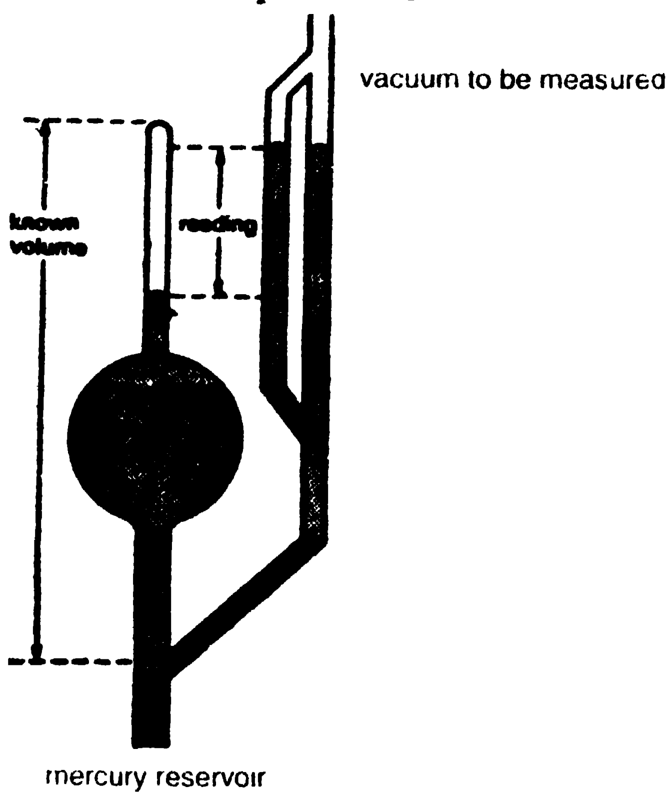
It is related to the deceleration parameter, q_0, by

$$\Omega_0 = 2q_0$$

If the universe is a continuously expanding open system, Ω_0 must be $\leqslant 1$; if it exceeds unity the universe is closed and must eventually collapse. The critical density for which Ω_0 is unity is 5×10^{-27} kg m^{-3} for a Hubble constant H_0 equal to 55 km s^{-1} megaparsec^{-1}. Various estimates involving the mass to luminosity ratios of galaxies lead to values for Ω_0 of about 0.01 due to galaxies. The missing-mass problem for clusters of galaxies indicates the presence of dark matter and suggests that the true value is about 0.3. A value of unity is not

precluded by these observations; many theoretical cosmologists believe that $\omega_0=1$ precisely, since any deviation from unity in the early universe would have been immensely amplified in the proposed inflationary phase.

Mcleod Gauge. A vacuum pressure gauge in which a relatively large volume of a low pressure gas is compressed to a



McLeod gauge

small volume in a glass apparatus. The volume is reduced to an extent that causes the pressure to rise sufficiently to support a column of fluid high enough to read. This simple device, which relies on Boyle's law, is suitable for measuring pressures in the range 10 to 10^{-2} pascal.

Mean Free Path. The average distance travelled between collisions by the molecules in a gas, the electrons in a metallic crystal, the neutrons in a moderator, etc. According to the kinetic theory the mean free path between elastic colisions of gas molecules of diameter d (assuming they are rigid spheres) is $1/\sqrt{2}n\pi d^2$, where n is the number of molecules per unit volume in the gas. As n is proportional to the pressure of the gas, expressed in joules and J therefore has a value of 1.

Mean Free Time. The average time that elapses between the collisions of the molecules in a gas, the electrons in a crystal, the neutrons in a moderator, etc.

Mean Life: Average Life. The average lifetime for an atomic or nuclear system in a specified state. For an exponentially decaying system it is the average time for the number of atoms or nuclei in a specified state to decrease by a factor of e (2.718 ..) This is 1/ln 2 times the half-life and for a radioactive nuclide it is the reciprocal of the disintegration constant.

Mean Parallax. The parallax obtained by statistical methods for a group of stars with different apparent magnitudes and proper motions.

Mean Solar Day. Day.

Mean Solar Time. Time measured with reference to the uniform motion of the mean sun. The mean solar day is the interval of 24 hours between two successive passages of the mean sun across the meridian. The mean solar second is 1/86 400 of the mean solar day. The difference between mean solar time and apparent solar time on any particular day is the equation of time. Since the mean sun is an abstract and hence unobservable point, mean solar time is defined in terms of sidereal time. One mean solar day is equal to 24th 3m 56.555s of mean sidereal time.

Mean solar time was originally devised in order to provide a uniform measure of time based on the earth's rate of rotation, which was assumed, incorrectly, to be constant. The sun's mean daily motion does however conform closely to universal time.

Mean Speed. The value of $\sum_{r=1}^{n} (n_r v_r)/n$ where in a system of n particles, n_1 of them have speed v_1, n_2 of them speed v_2 and so on.

Mean Square Speed. The value of

$$\sum_{r=1} (n_r v_r^2)/n$$

where in a system of n particles, n_1 of them have speed v_1, n_2 of them have speed v_2 and so on.

Mechanical Advantage. Force ratio.

Mechanical Energy. The sum of the kinetic and potential energies of a body. It is constant for a conservative field of force.

Mechanical Equivalent of Heat Symbol J. The ratio of a unit of mechanical energy to the equivalent unit of thermal energy, when a system of units is used in which they differ. J has the value 4.1868×10^7 ergs per calorie. The concept loses its usefulness in SI units in which all forms of energy are (1831)−79) and Ludwig Boltzmann (1844−1906). One form of their law states that $n = N\exp(-E/RT)$, where n is the number of molecules with energy in excess of E, T is the thermodynamic temperature, and R is the gas constant.

Mechanical Equivalent of Light. A constant relating the Watt to the Lumen. The value for radiation of wavelength 555 nanometre is 660 lumen per watt.

Mechanical Filter. A filter that consists of an input transducer, bias magnets, resonant metal disks, nickel coupling rods, external capacitors, and an output transducer. SSB transmitters and receivers require very selective bandpass filters in the region of 100 to 600 kHz. The filters used must have very steep skirt characteristics and flat pass-band characteristics.

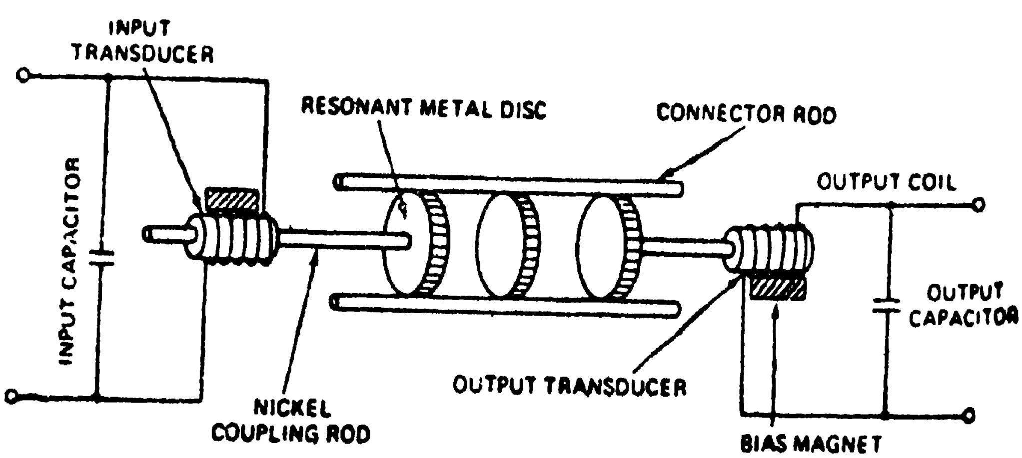
Basic crystal filters and filters made up of inductors, resistors, and capacitors are often used, but the mechanical filter is also used to satisfy the requirements of SSB equipment. Mechanical filters offer many advantages over LC crystal filters. They are small, have excellent rejection characteristics, and are comparatively rugged. The Q obtainable with a mechanical filter is much greater than that obtained with an LC filter.

Fig. illustrates a basic mechanical filter. The input transducer converts electrical energy to mechanical energy by

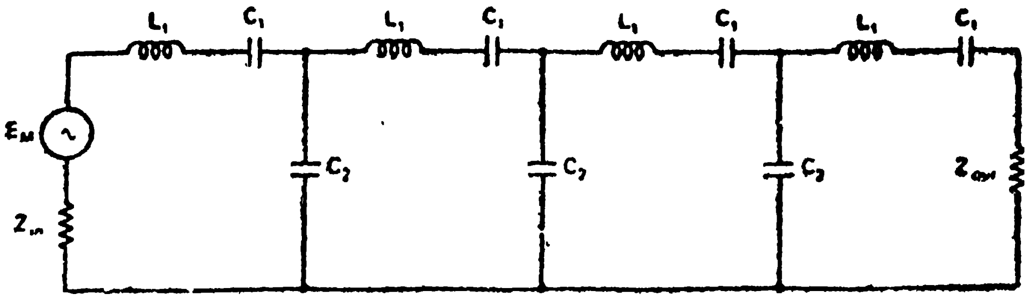
utilizing the magnetostiction effect. The mechanical oscillations of the input transducer are transmitted to the coupling rods and metal disks. Each disk acts as a mechanical series resonant circuit. The disks are designed to resonate at the center of the filter's passband. The number of disks determines the skirt selectivity. Skirt selectivity is specified as shape factor, which is the ratio of the passband 60 dB below peak to the passband 6 dB below peak. Practical manufacturing presently limits the number of disk to eight. A six-disk filter has a shape factor of approximately 2.2; a seven-disk filter, 1.85; and an eight disk filter, 1 5.

The passband of the filter is primarily determined by the area of the coupling rods. Passband may be increased by using more or larger coupling rods. Mechanical filters with bandwidths as narrow as 0.5 kHz and as wide as 35 kHz are practical in the 100 to 600 kHz range.

A terminal disk vibrates the output transducer rod, which induces, by means of generation action, a current in the output transducer coil. The external capacitors are used to form parallel resonant circuit with the input and output transducer coils at the filter frequency. The equivalent circuit for the filter in Fig. C_1 and L_1 represent a resonant metal disk; C_2 represents the coupling rods.



Mechanical filter



Equivalent circuit of the mechanical filter shown in Fig

Mechanical Impedance. The ratio of the (complex) force acting on a given area of an acoustic medium or mechanical device to the resulting linear velocity in the direction of the force. The units are the mechanical ohm (dyne s cm^{-1}) or the MKS (and SI) mechanical ohm (N s m^{-1}).

Mechanics. The study of the interactions between matter and the forces acting on it. Statics is broadly concerned with the action of forces when on change of momentum is concerned, while dynamics deals with cases in which there is a change of momentum. Kinematics is the study of the motion of bodies without reference to the forces causing the motion. These classical sciences are concerned with macroscopic bodies in the solid state, while fluid mechanics is the science of the interaction between forces and fluids.

Mechanocaloric Effect. The increase in temperature of helium II in a tube when some of the helium II flows out through a porous plug. Conversely, the cooling of helium II when some of it flows into a tube, closed by a porous plug, which is plunged into the liquid. The temperature change in each case is about 0.01 deg.

Medical Physics. The application of physics to medicine, for example in Radiotherapy, Nuclear Medicine and Diagnostic Physics.

Medium. The nature of the space through which something is transmitted or propagated. It may be solid, liquid,

gas, or a vacuum (although some people do not class a vacuum as a medium).

Medium Frequency (MF). A radio frequency in the range 0.3—3 megahertz; *i e.* having a wavelength in the range 100—1000 metres.

Mega

1. Symbol M. A prefix meaning 10^6, *i.e.* one million.
2. A prefix used in computing to mean 2^{20}; thus 1 megabyte is equal to 1 048 576 Byte.

Megaphone. An instrument for amplifying and directing sound. It consists of a horn about a third of a metre long, into whose short end speech is directed.

Megelecton Volt. Symbol MeV. One million electron volt.

Megaton. A unit used to express the explosive power of nuclear weapons. One megaton is an explosive power equivalent to that of one million tons of TNT.

Megaton Weapon. A nuclear weapon with an explosive power equivalent to one million tons of TNT. Compare kiloton weapon.

Megger. A test instrument frequently used for measuring resistance. The name comes from the fact that the instrument is commonly used to measure resistances of millions of ohms, and a million homs of resistance is called a megohm. Most meggers consist of a small hand or battery-driven dc generator and one or more meter elements enclosed in a housing. When the crank is turned or the generator motor is activated, the generator will produce from 100 to 1000-V dc depending on the speed at which the generator is rotated and the number of coil turns in its winding.

Normal operating voltage is from 300 to 500 V. and this is marked on the meter scale. Some of these instruments are manufactured with a built-in voltohmmeter to show the generator voltage and indicate the

insulation resistance of the circuit under test. One terminal of the instrument can be connected to the terminal of a motor, for example, and the other to the motor frame. When the crank is turned or the generator is activated by an electric motor, the insulation resistance in megohms can be read directly from the scale.

Megahertz A unit of frequency that is equivalent to 1,000,000 cycles/s, or 1,000,000 Hz. It is also equivalent to 1000 kHz.

Meissner Effect. Concerns the behaviour of a superconductor as a perfect diamagnetic in a magnetic field. When a superconductor is cooled in a magnetic field from above the critical temperature to below that temperature the magnetic flux in expelled from the material with a sudden change in the field strength outside.

Mekometer. An electronic device for the measurement of distances by means of a light beam modulated at microwave frequency. It is based on the Pockels effect and employs gigal frequencies (much higher than those employed by the Geodimeter and Tellurometer) and is therefore suitable for the highly accurate measurement of short distances. It can achieve an accuracy of 1 part in 10^6.

Melloni Thermopile. An early form of thermopile consisting of a block of antimony and bismuth.

Melting (fusion). The change from the solid to the liquid state. For a pure crystalline substance this happens at a characteristic temperature—the melting point (or freezing point). This temperature depends on pressure, but is usually quoted at standard atmospheric pressure. The melting point of a substance is lowered by the presence of impurities.

Melting Curve. A curve showing the variation of melting point with pressure.

Melting Point (m.p.). The temperature at which a solid changes into a liquid. A pure substance under standard

conditions of pressure (usually 1 atmosphere) has a single reproducible melting point. If heat is gradually and uniformly supplied to a solid the consequent rise in temperature stops at the melting point until the fusion process is complete.

Membrane. A thin layer of tissue which covers a surface or divides a space or organ.

Meniscus. The curved surface of a liquid in a tube or other container. The curvature is due to capillary action, the sense of the curvature depending on the angle of contact between the liquid surface and the material of the container.

Meniscus Lens. A lens in which the two surfaces have different or sometimes equal curvatures but, unlike a concave or convex lens, curve in the same general direction. A positive meniscus is thicker at the centre than at the edges; a negative meniscus is thinner at the centre.

Mercalli Scale. A scale of earthquake intensity.

Mercury. The nearest planet to the Sun. Its mass is about 0.05 and its diameter 0.38 times Earth's. Its axial period of rotation is 58 6 day any its orbital period is 88 day. Mercury is difficult to observe and can only be seen as a morning or evening star.

Mercury Barometer. Barometer.

Mercury Cell. A primary voltaic cell consisting of a zinc anode and a cathode of mercury(II) oxide (HgO) mixed with graphite. The electrolyte is potassium hydroxide (KOH) saturated with zinc oxide, the overall reaction being :

$$Zn + HgO \rightarrow ZnO + Hg$$

The e.m.f. is 1.35 volts and the cell will deliver about 0 3 ampere-hour per cm^3.

Mercury in Glass Thermometer. An instrument produced by introducing mercury into a fine glass capillary tube with a bulb attached at one end : a mercury reservoir is

attached to the open end of the capaillary and by alternately heating the bulb and allowing it to cool, mercury is drawn in until the bulb and about a third of the capillary are filled with mercury; the bulb is then heated so that any remaining air is expelled, leaving a small space at the top of the tube as a precaution against breakage should the thermometer be exposed to excessively high temperatures.

The thermometer is calibrated by marking the mercury meniscus position for immersion first in melting ice and then in steam in a Hypsometer, correcting to normal pressure For a Celsius thermometer, the space between the marks is divided into 100 equal parts. Since the expansivity of mercury is temperature dependent and since the glass expansion is not neglibible, thermometer readings can only be corrected to the gas scale by direct comparison with the readings of a Constant Pressure or Constant Volume Gas Thermometer.

Mercury Lamp. A lamp that produces light with a predominance of yellow and green rays, combined with a small percentage of violet and blue. When lighted, this type of lamp appears to emit white light (red, blue, and green), but the red colour is absent. Therefore, red objects appear black or dark brown under mercury lamps. This color distortion has in the past prevented its use in many applications. However, it has now been overcome to a certain extent by the use of red light-generating chemicals within the bulb. Consequently, this type of lamp is now finding its way indoors for more and more commercial lighting applications.

Mercury Thermometer. A liquid-in-glass thermometer that uses mercury as its working substance. It consists of a thin capillary tube graduated in degrees, at the base of which is a bulb containing mercury. When the temperature rises, the mercury expands up the tube. The level indicates the temperature.

Mercury Vapour Lamp. Essentially a Gas Discharge Tube in which the discharge occurs in mercury vapour. Both low- and high-pressure lamps are available; the 365 nanometre ultraviolet line is strong for both lamps, but the 253.7 nanometre line suffers reversal in the high-pressure lamp.

Mercury-zinc Battery. A source of power that employs a zinc-powder anode and a cathode comprised of a mercuric-oxide power and a graphite power. It is one of the most expensive types of power supplies. The mercury-zinc battery has extremely uniform output throughout its life, characterized by a high-current capacity in a relatively small space and a continuous-current be easily pulled from the conductors. An insulating bushing, sometimes called a redhead, is used to protect the insulated conductors from the sharp edges of the metal jacket (sheathing) where the cut was made.

Meridian

1. In astronomy : the great circle on the celestial sphere which passes through its poles and through the zenith of the observer.
2. Of a point on the Earth's surface : the plane including the Earth's axis and the point in question. It is also called a meridian of longitude.

Meridian Circle : Transit Circle. An instrument for the precise determination of the right ascension and declination of a celestial object. It is the fundamental instrument of positional astronomy and consists ideally of a rigid refracting telescope mounted with its optical axis accurately constrained in the meridian plane The telescope may be rotated about an east west line in this plane and its setting accurately determined. The position of the object under observation is determined from a recording of the time and zenith distance at which it crosses the meridian. In the mirror transit circle the

telescope is replaced by a rotatable mirror and the object under observation is viewed by one or other of two horizontally mounted telescopes.

Meridian, Magnetic. Magnetic meridian.

Meridian Plane

1. Of the Earth or the celestial sphere : any plane passing through the poles.
2. Of an optical system : any plane containing the optic axis.

Meridian Transit. The passage of a celestial body across the meridian of an observer. Measurements of the times at which meridian transits occur are commonly used to determine longitude.

Merton Nut. A nut whose threads are made of a substance sufficiently elastic (*e.g.* cork) to take up the errors of a screw. No threads are, or can be, cut, they are formed by compressing the material into the screw. The use of this elastic nut permits the cutting of screws which are free from periodic errors. Other errors are averaged out.

Merz Slit. A variable width bilateral slit for spectrographs, in which the centre of the slit remains in a fixed position.

Mesic Atom.

1. A transient system insisting of a normal atom in which one of the orbital electrons is replaced by a negative meson. It is known as muonium.
2. A transient's system consisting of an atom in which the nucleus is replaced by a positive meson. It is known as pionium.

Meson. One of a series of particles of mass intermediate between that of an electron and that of a proton. These particles may be regarded as the quantum particles of the strong interactions between the baryons. The term usually

embraces only the "long-lived" mesons (typically greater than about 10^{-10} s), the "short-lived" mesons (typically about 10^{-23} s) being known as meson resonances. The mesons, in ascending order of mass, are shown in the following table :

Particle	Mass (MeV)	Charge and symbol	Mean life (sec)
Muon	106	Positive (μ^+)	2.2×10^{-6}
		Negative (μ^-)	2.2×10^{-6}
Pion	138	Positive (π^+)	2.56×10^{-8}
		Negative (π^-)	2.56×10^{-8}
		Neutral (π^0)	10^{-16}
Kaon	496	Positive (K^-)	1.23×10^{-8}
		Negative (K^+)	1.23×10^{-8}
		Neutral (K^0) and anti-particle $\bar{K}^0$)	K_1^0 : 0.9×10^{-10} K_2^0 : 6×10^{-8}

(*Note* : the neutral kaon behaves as mixture of K^0 and $\bar{K}^0$, K_1^0 as a symmetric mixture, and K_2^0 as an antisymmetric mixture of wave functions.)

Meson-nucleon Coupling Constant. A number which, in the meson theory of nuclear forces, is a measure of the strength of interaction between the meson and nucleon involved.

Meson Theory of Nuclear Forces. A theory which explains the short-range (about 10^{-13} cm) nucleon-nucleon forces in the nucleus in terms of the exchange of a particle between them. The particle, originally postulated by Yukawa, was subsequently discovered and called a meson. Various mesons are now known, but that principally concerned in nucleon-nucleon forces is the π-meson, sometimes termed the nuclear force meson. These mesons are the free quanta of the meson field as photons are the free quanta of the electromagnetic field. The meson theory of nuclear forces aims to relate the properties of such mesons to the characteristics of the nuclear forces involved.

Mesopause. The upper limit of the Mesosphere.

Mesosphere. The part of the atmosphere extending from about 55 kilometre to about 80 kilometre above the Earth's surface.

Metacentre. The point of intersection of a vertical line through the Centre of Buoyancy of a titled floating body with the line joining the centre of mass and the position of the centre of buoyancy for the body when upright. Provided the metacentre is higher than the centre of mass of the body, the body tends to return to the upright position.

Metagalaxy. The total recognized assemblage of galaxies. It is essentially the measurable material Universe, and includes whatever there may be in the way of gas, particles, planets, stars and star clusters in the spaces between the galaxies.

Metal. An element characterized by the presence of relatively free electrons, and hence by high thermal and electrical conductivity, opacity and optical reflecting power or "lustre". The distinction between metals and non-metals is, however, not sharp in certain instances.

Metal Fatigue. A cumulative effect causing a metal to fail after repeated applications of stress, none of which exceeds the ultimate tensile strength. The fatigue strength (or fatigue limit) is the stress that will cause failure after a specified number (usually 10^7) of cycles. The number of cycles required to produce failure decreases as the level of stress or strain increases. Other factors, such as corrosion, also reduce the fatigue life.

Metal-glass Seal. A type of seal required in many pieces of apparatus; frequently vacuum tightness is needed. It is necessary to make the seal when the glass is soft, *i.e.* at high temperature, and so, to prevent cracking on cooling, glass and metal of roughly the same expansion coefficient are ideally required. Soft glass and copper-coated nickel-iron alloy form a suitable combination for small jobs. When larger joints are to be made, such as of glass and

metal tubes of several centimetres diameter in a vacuum plant, a tapered copper tube is used; the copper in contact with the glass is then thin enough to suffer the distortion resulting from the difference in expansion coefficients without cracking the glass.

Metallic Bond. The type of Bond occurring in metallic crystals : a regular lattice of positive ions is held together by a cloud of free electrons which move through the lattice.

Metallic Line Stars. Stars whose spectra resemble those of class A stars, but have stronger metallic lines. Such stars are usually placed in class A but their metallic lines correspond to about class F.

Metallic Transformations. Changes in the configuration of the atoms in a metal by the alteration of the external constraints in such a way that the initial configuration becomes less stable than another configuration. The are usually classified by the growth process involved into nucleation and growth transformations, in which diffusion plays the main part, and martensitic transformations, in which distortion plays the main part.

Metallizing. The process of covering insulating material with a film of metal in order to make it electrically conducting. The technique is of importance in solid-state electronics.

Metallography. The microscopic study of the structure of metals and their alloys. Both optical microscopes and electron microscopes are used in this work.

Metalloid. An element in whose properties both metallic and non-metallic behaviour can be discerned.

Metallurgy. The study of metals and their alloys, including their structure, properties and industrial processes of smelting, refining and working.

Metal-oxide Semiconductor. A device that has been fabricated through a technique whereby a metallized electrode or

gate is insulated from a semiconductor substrate material by using a dielectric to form a unipolar area. MOS devices have been ushered in by the advancements made in integrated circuit technology, which made possible the placement of large shift registers on a single chip. Elaborate MOS devices may contain as many as 5000 gates on a single chip measuring 4 mm^2. MOS logic is used for pocket calculator chips, as well as for IC computer or microprocessor devices and random-access memories.

Metal-oxide Semiconductor Field-effect Transistor. A field-effect transistor (FET) in which the gate electrode consists of a thin metal film insulated from the semiconductor channel by a thin oxide film. Often abbreviated MOSFET, these devices fall into two categories—the depletion type and the enhancement type. Charge carriers are present in the channel of the depletion type when no bias voltage is applied to the gate. In the enhancement type, a forward-biased gate is necessary to produce active carriers. Each type is available with N-channel or P-channel polarization.

Metal Rectifier. A plate of metal in contact with its oxide, or other suitable compound, which offers much greater resistance to current flow in one direction than in the opposite direction; examples are the Copper Oxide Rectifier and the Selenium Rectifier. Such devices are unsuitable for potentials above a few volt, so for high voltages a bank of rectifiers in series is used. The current passed depends on the area of contact.

Metamict State. The amorphous state of a substance that has lost its crystalline structure as a result of the radioactivity of uranium or thorium. Metamict minerals are minerals whose structure has been disrupted by this process. The metamictization is caused by alpha-particles and the recoil nuclei from radioactive disintegration.

Metamorphism. The recrystallization of rocks within the Earth's crust by heat and stress.

Metasrable State. A condition of a system or body in which it appears to be in stable equilibrium but, if disturbed, can settle into a lower energy state. For example, supercooled water is liquid at below 0°C (at standard pressure). When a small crystal of ice or dust (for example) is introduced rapid freezing occurs.

Meteor. A lump of matter which enters the Earth's atmosphere from space. The composition is variable but there is a preponderance of iron and nickel alloys. Due to friction from air particles, the surface temperature of a meteor reaches about 3000K and so the meteor appears luminous. Generally a meteor leaves a trail of ionized gas in its wake.

Meteorgraph. A device used in Meteorology for recording temperature, relative humidity, pressure or wind speed or some combination of these. Often such devices are launched into the upper atmosphere by balloon or by kite.

Meteorite. A very large Meteor, part of which strikes the Earth's surface, the remainder having been burnt off in its passage through the atmosphere. The mass reaching the Earth's surface may vary from a few gramme up to 65000 kilogramme, as found at Grootfontein, South Africa.

Meteorology. The science of the atmosphere, especially concerned with weather and climate.

Meteor Radiant. The point in the atmosphere from which visible tracks of shower meteors appear to diverge. The appearance arises from the parallel motion of the meteors and is the effect of perspective. The position of the radiant is fixed relative to the fixed stars each time the shower reappears, and a shower may therefore be identified by the name of the constellation nearest to it. Typical names of such showers are the Perseids, Orionids, Geminids, etc.

Meteors. Stony or metallic bodies travelling in elliptical orbits round the Sun. Those groups moving in apparently unrelated orbits are termed sporadic meteors, and those

moving in very similar orbits and reappearing at the same time each year form a number of meteor streams, and are known as shower meteors. When a meters enters the Earth's atmosphere it produces ionization (meteor ionization), which is detectable by radar. It also becomes incandescent, and is seen as a shooting star.

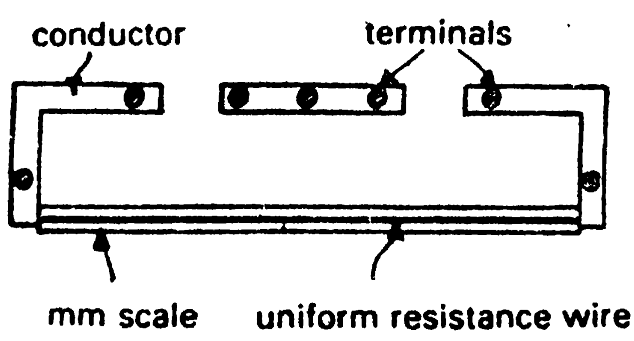
Method of Mixtures. A method of determining the specific heat capacities of liquids or a liquid and a solid by mixing known masses of the substances at different temperatures and measuring the final temperature of the mixture.

Metre. Symbol : m. The usual scientific unit of length and distance. It is defined (from Oct. 1983) as the length of the path travelled by light in vacuum during a time interval of

1/299 792 458 of a second

It is thus now defined in terms of the second and the fixed value of the speed of light. The metre was formerly the length equal to 1 650 763.73 wavelengths in vacuum of the radiation corresponding to the transition between the levels $2p_{10}$ and $5d_5$ of the krypton-86 atom. This definition came into use in 1960. Before that, the metre was the length of a prototype metre bar.

Metre Bridge A metre length of uniform resistance wire mounted above a scale marked in millimetres, with suitable terminal points added to make the device adaptable either as a Wheatstone bridge or a potentiometer. As a Wheatstone bridge the wire acts as two arms of the bridge



Metre bridge

resistors; and as a potentiometer the potential drop along the wire is proportional to the length of wire.

Metre-candle. A unit of illumination, equal to the lux, *i.e.*, 1^2.

Metric System. A system of units based on the metre and the kilogram and using multiples and submultiples of 10. SI units, c.g s. units, and m.k.s. units are all scientific metric systems of units.

Metric Ton (tonne). A unit mass equal to 1000 kg or 2204.61 lb. 1 tonne=0.9842 ton.

Metrology. The scientific study of mea surement, especially the definition and standardization of the units of measurement used in science.

MeV. Symbol for milli-electronvolt.

MeV. Symbol for Megelectron Volt.

MF. Abbrev. for medium frequency.

Meyer Hardness Number. For the Brinele test : the load divided by the projected area of the indent. The value of this number when the indenting ball is immersed to its equator is known as the ultimate ball hardness, and is a constant for the material under test. The variation of Meyer hardness number with the shape of the impression is a measure of the ability of a material to be cold worked.

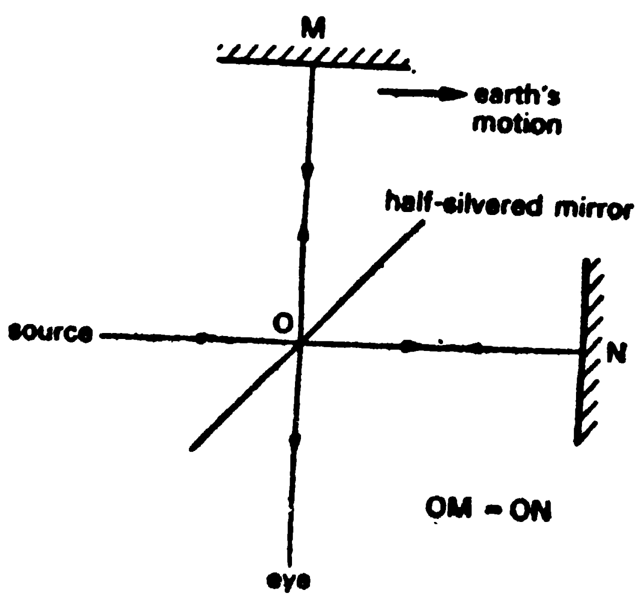
Mhd. Abbrev. for Magnetohydro-dynamics.

Mho. A reciprocal ohm, the former name of tha unit ofelectrical conductance now known as the siemens.

Mica. A mineral which is composed of complex silicates and readily splits into very thin plates. It has low thermal conductivity and high dielectric strength and so is widely used for electrical insulation.

Mica Capacitor. A capacitor consisting of alternate layers of mica and plate material. The capacitance is of a small value, usually in the picofarad range. Although small in physical size, mica capacitors have a high voltage-handling capacity. Fig shows a cutaway view of a mica capacitor.

Michelson-morley Experiment. An experiment, conducted in 1887 by Albert Michelson (1852—1931)) and Edward Morley (1838—1923), that attempted to measure the velocity of the earth through the ether. Using a modified Michelson interferometer they expected to observe a shift in the interference fringes formed when the instrument was rotated through 90°, showing that the speed of light measured in the direction of the earth's rotation, or orbital motion, is not identical to its speed at right angles to this direction. No shift was observed. An explanation was finally provided by the Lorentz—Fitzgerald contraction, which was an important step in the formulation of Einstein's special theory of relativity and the abandonment of the ether concept.



Michelson interferometer

Michelson Stellar Interferometer. An interferometer designed to be placed on a telescope and used to measure the angular diameter of a star.

Micro- Symbol : μ. A prefix denoting 10^{-6}. For example, 1 micrometre (μm)$=10^{-6}$ metre (m).

Microbalance. A beam Balance capable of measuring masses as low as 10^{-8} gramme. A bulb is fixed to one end of the beam. Balance is secured by varying the air pressure in the balance case thus changing the [illegible] of buoyancy on

the bulb. At constant temperature this force is proportional to the pressure, which is measured at balance by a manometer.

Microcalorimeter. A differential calorimeter used for measuring very small quantities of heat, such as those associated with bacterial growth.

Microdensitometer : Microphotometer. An instrument, which may or may not be of the recording type, for the measurement of the absorption of light in successive small areas of a specimen, by the determination of the optical density. Most microdensitometers are designed for measuring densities on a photographic plate, but may also be designed for direct use on, for example, biological specimens, where such things as the distribution of pigment may be of interest.

Microelectronics The techniques of designing and making electronic circuits of very small size. As a result of these techniques a single silicon chip measuring less than a centimetre in either direction can contain many thousands of transistors and may constitute the central processing unit of a microcomputer. In addition to an enormous drop in size, compared to an equivalent valve-operated device, these microelectronic circuits are some 100 000 times more reliable than their thermionic predecessors.

Microfocus X-ray Tube. An X-ray tube, as its name implies, having a very fine focus. The object of such a tube is to provide a high intensity beam, which is achieved at a small power input, owing to the high specific loading and rapid dissemination of heat.

Microgravity. The very low gravity encountered on spacecraft in earth orbit.

Micromanometer A device for measuring very small pressure differences. An example is the diaphragm gauge in which the diaphragm displacement produced by the pressure difference is measured optically.

Micrometer. A gauge for measuring small diameters, thicknesses, etc., accurately. It consists of a G-shaped device in which the gap between the measuring faces is adjusted by means of an accurately calibrated screw, the end of which forms one of the measuring faces.

Micrometer Eyepiece. Generally a Ramsden Eyepiece whose cross wires can be displaced by means of a Micrometer Screw, thus enabling small distances to be accurately measured.

Micrometer Screw. A device for the accurate measurment of distance. It employs a calibrated drum, which on rotation advances or retracts a screw of known pitch; from the difference of the drum readings, the distance moved can be accurately found.

Micron. Symbol : μm A unit of length equal to 10^{-6} metre.

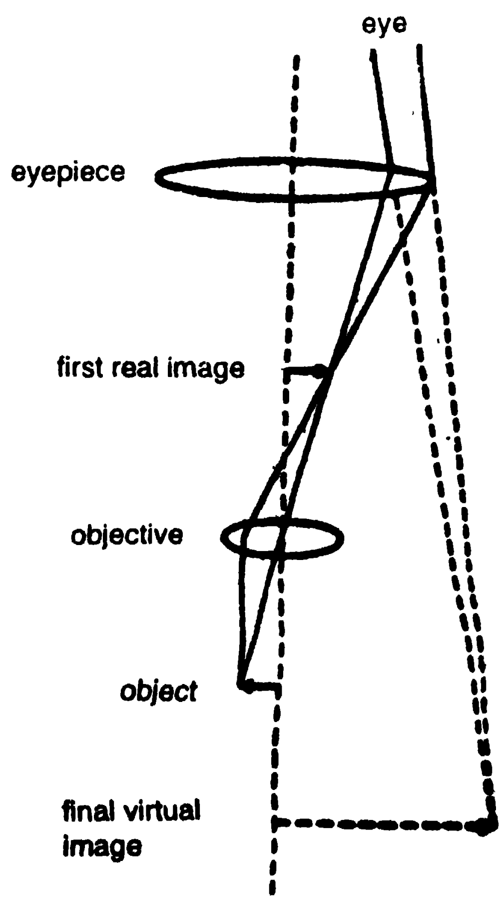
Microphone. A transducer in which sound waves are converted into corresponding variations in an electrical signal for amplication, transmission to a distant point, or recording. Various types of device are used. In the dynamic microphone the sound waves impinge on a conductor of low mass supported in a magnetic field and cause it to oscillate at the frequency of the sound waves. These movements induce an e.m.f. in the conductor that is proportional to its velocity. The moving conductor consists of a metal ribbon, a wire, or a coil of wire. In the moving-iron microphone, sound waves cause a light armature to oscillate so that it varies the reluctance of a magnetic circuit. In a coil surrounding this path the varying reluctance is experienced as a variation in the magnetic flux within it, which induces a corresponding e.m.f. In the carbon microphone, widely used in telephones, a diaphragm constitutes a movable electrode in contact with carbon granules, which are also in contact with a fixed electrode. The movement of the diaphragm, in response to the sound waves, varies the resistance of the path through the granules to the fixed electrode.

Microphotography. The production of microscopic images on high-resolution photographic emulsion. It should not be (but often is) confused with photomicrography.

Microprojection. The use of the optical system of a compound microscope to project on to a screen an image of an object situated on the microscope stage.

Microradiography. The radiography of thin sections of material in such a way that the resulting image may be enlarged to reveal microstructure. In contact micreradiography the section is placed in contact with a high-resolution photographic emulsion. In projection microradiography direct magnification is obtained by increasing the distance between the section and the film, and using a point source of X-rays.

Microscope. A device for forming a magnified image of a small project. The simple microscope consist of a bicconve magnifying glass or an equivalent system of



Compound microscope

lenses, either hand-held or in a simple frame. The compound microscope uses two lenses or systems of lenses, the second magnifying the real image formed by the first. The lenses are usually mounted at the opposite ends of a tube that has mechanical controls to move it in relation to the object. An optical condenser and mirror, often with a separate light source, provide illumination of the object. The widely used binocular microscope consists of two separate instruments fastened together so that one eye looks through one while the other eye loooks through the other. This gives stereoscopic vision.

A binocular microscope is a compound microscope with two eyepieces.

A stereoscopic microscope consists of two compound microscopes, one for each eye, so that an impression of image depth is obtained.

An interference microscope is a compound microscope used for a specimen with no appreciable absorption. Interference occurs between part of a beam which has passed through the object and another part which enters the microscope directly. Details in the object are much enhanced by the use of this instrument.

A phase contrast microscope is a type of interference microscope in which a path difference between beams is obtained by using a Phase Plate.

A polarising microscope is a microscope in which the object is illuminated by plane polarized light: the eyepiece is fitted with an Analyser which can be rotated. An object with the same properties throughout has a uniform appearance when viewed. A non uniform object may present an image of greater contrast than is obtainable using an ordinary microscope; study of this image can yield information about the molecular structure of the object. Insertion of a suitably mounted graduated quartz wedge in the beam from the microscope objective enables thinkness measurements to be made on suitable specimeans. A great

advantage of the polarizing microscope is that, since staining is unnecessary, observations can be made on living cells and hence processes such as cell division can be observed.

An ultraviolet microscope is a compound microscope in which ultraviolet light is used to illuminate the object and so obtain an increase in Resolving Power due to the shorter wavelength. It is necessary to record the image photographically.

An X-ray microscope is a compound microscope in which the object illuminated with X-rays and so greater resolving power can be obtained than with the ultraviolet microscope. Physical recording of the image is required.

Microscope, Simple. The magnifying glass, or simple magnifier. The small object is viewed between the lens and its focal point; an upright virtual image is obtained. In this case the image is placed at the near point of the eye—the magnifying power is then given by $(D/f)+1$, where D is the near-point distance and f the lens focal distance. The lens can also be used to give an image at infinity; the image is then viewed with the relaxed eye, but the magnifying power is only D/f.

Microscopic.

1. Visible only with the aid of a microscope.
2. Concerned with the behaviour of individual atoms or molecules rather than with that of matter in bulk. Compare Macroscopic.

Microscopy. The study of the construction and use of the various types of Microscope.

Microseisms. Small continuous movements of the ground, detectable by sensitive seismographs. Most arise from local sources, but microseism storms occur simultaneously over wide areas of the Earth's surface and often accompany hurricanes, cold fronts, and large-scale depressions. They may also be correlated with waves at sea.

Microspectrometry. The process of obtaining spectrometric or spectrophotometric information about microscopically sized objects.

Microtron An electron accelerator operating on a modified cyclotron principle.

Microwave. A form of electromagnetic radiation that has frequencies of one billion hertz. These high-frequency bands of energy are used extensively for radar and wideband communications. More recently, they have been employed in such devices as microwave ovens. The radiation of microwaves can be directed into very narrow beams of energy, which makes these ranges very efficient in the utilization of transmitter energy. Interference between communication systems is also minimized. The extremely small wavelengths require relatively smaller antennas than other forms of transmitted energy. However, because of their shorter wavelength, microwaves are more susceptible to weather effects, such as raindrops, which become small antennas that absorb the energy and cause it to be dissipated before it reaches its destination.

Microwave Background. An isotropic distribution of Microwave radiation throughout the universe. It corresponds to Black Body radiation of temperature 2.7 K and is almost certainly a relic of the big bang postulated as the origin of the universe.

Microwave Background Radiation. A background of radiation in the frequency range 3×10^{11} hertz to 3×10^{8} hertz discovered in space in 1965. Believed to have emanated from the primordial fireball on the big bang with which the universe is thought to have originated.

Microwave Optics. The study of the behaviour of microwaves by analogy with the behaviour of light waves. On the large scale microwaves are propagated in straight lines and, like light waves, they undergo reflection, refraction, diffraction, and polarization.

Microwave Radio. A system in which long-distance telephone calls and television broadcast programs are relayed by means of microwave-radiated energy bands. Since microwaves are susceptible to weather interference, repeater or relay stations are placed at various places that receive the signals from various other stations, boost their power, and transmit the signals onto other relay stations

Microwave Reflectometer. An instrument for the study of travelling wave phenomena in transmission lines. It depends on the measurement of the incident waves and the reflected waves produced by a discontinuity.

Microwaves. A form of electromagnetic radiation, ranging in wavelength from about 1 mm (where it merges with infrared) to about 120 mm (bordering on radio waves). Microwaves are produced by various electronic devices including the klyston; they are often carried over short distances in tubes of rectangular section called wave guides.

Microwave communication was until recently the most efficient form of electronic telecommunication. Since the development of cheap lasers and optical fibres, telecommunication at visible wavelengths is developing rapidly. Radar systems generally use microwaves, while their ability to carry energy has a number of applications, including microwave cookers.

Microwave Spectroscopy. The measurement of spectral lines in the wavelength range of about 10 cm to 0.5 mm (*i.e.* in the frequency range of about 3000 to 600 000 MHz). In its simplest form a microwave spectrometer consists of a klystron (to produce highly monochromatic radiation), an absorption cell and a suitable detector (*e.g.* a silicon—tungten crystal detector), to measure the change of absorption with frequency. There are two basic kinds of spectroscopy in the micrwave region, electron paramagnetic resonance and geseous microwave spectroscopy, which are defined separately.

Microwave Spectrum. An emission or absorption spectrum in the Microwave region. From such spectra information about molecular dimensions and moments of inertia can be deduced.

Microwave Ultrasonics. Artificially generated very high frequency vibrations in solids. They are similar in nature to thermal vibrations and are sometimes known as microwave phonons. They are, however, unlike thermal phonons, coherent, polarized in a given direction, and have a single frequency.

Mie Scattering. The scattering of light by spherical particles of diameters comparable with the wavelength of the light. It is an extension of Rayleight Scattering.

Migration Area. For a fission neutron in an infinite homogeneous medium: the sum of the slowing down area from fission energy to thermal energy and the diffusion area from thermal energy to capture. It is one-sixth of the mean square displacement of the neutron from its point of origin to its point of capture.

Migration Length. For a fission neutron in an infinite medium: the square root of the migration area.

Mil

1. A thousandth of an inch.
2. A thousandth of a litre.
3. Short for Circular Mil.

Mile

1. A statute mile : equal to 1760 yd (1.609344 km exactly).
2. A nautical mile : equal to 1/60 of a degree of latitude at the equator, *i.e.*, 6080 ft (about 1·853 km), but often taken as 2000 yd (1.8288 km).

Milky Way. A dense band of faint stars that extends right round the celestial sphere, dividing it into roughly equal parts Its central line marks the central plane of our

Galary, inclined at 62° to the celestial equator. Although the vast majority of the stars are too faint too be seen individually, they are collectively visible on a clear moonless night as a diffuse band of light. The milky Way is seen because the sun lies close to the central plane of the galactic disc. Since this region of the Galaxy is highly flattened, a much greater depth of stars is visible in directions along the plane (*i.e.* towards the Milky Way) than in other directions. The Milky Way has a distinctly patchy appearance; it also varies considerably in width and brightness and is noticeably brighter towards Sagittarius (the direction of the galactic centre). Many of the apparent gaps are due to dark nebulae, such as the Coalsack, along our line of sight, which prevent stars behind them from being seen.

Miller Indices. Indices specifying a crystallographic plane. They are the reciprocals of the intercepts made by the plane on the crystallographic axes, expressed in terms of the axial length and as the simplest proportional whole numbers, a prominent crystal face (the parametral plane) being defined as the (111) plane. In diffraction work the term is extended to mean the reciprocals of the intercepts made by a plane on the unit cell axes. The indices are then expressed in terms of the edges of the unit cell and not as the simplest proportional whole number. Thus (110), (220) and (330) describbe three parallel planes.

Milli-Symbol: m A prefix denoting 10^{-3}. For example, 1 millimetre (mm)$=10^{-3}$ metre (m).

Milliammeter. An instrument for measuring electric currents of a few milliammperes.

Millikan's Electronic Charge Determination. The first measurement of the charge on the electron. The apparatus used, illustrated in fig. was mounted in a constant temperature enclosure. A and B represent horizontal circular plates each of about 20 centimetre diameter and separation 1 5 centimetre; A has a small hole at the centre. Occasionally one oil drop would pass through the hole in A.

The illuminated drop was observed as a pin point of light through a low-power compound Microscope (not shown). The drop's terminal downward velocity was found for zero potential difference between A and B by timing the drop over a known distance indicated by a scale in the eyepiece. The observation was repeated in the presence of a potential difference between A and B which opposed the force due to gravity, and the upwards terminal velocity was measured. The observations were repeated on several drops, which could be given different charges by using a burst of X rays to ionize the air.

For each drop, the first observation permits the drop radius to be calculated by equating the weight of the drop to the sum of the viscous force and the upthrust due to the air acting on it. Using this radius value, the second observation permits the charge to be calculated by equating the sum of the weight of the drop and the viscous force acting on it to the sum of the electric force and the upthrust due to the air. Millikan found that the charge was always an integral multiple of its lowest value. This lowest value was therefore taken as the charge on the electron.

Millikan's Photoelectric Experiment. An experiment in which vacuum-mounted clean lithium, sodium and potassium surfaces were illuminated in turn with monochromatic light from a spectrometer. The applied potential necessary to stop the Photomission from each surface was measured. The results were in accordance with Einsteins Photoelectric Equation.

Milli-electronvolt. Symbol meV. One thousandth of an electronvolt.

Millimetre of Mercury. The pressure that will support a column of mercury one millimetre high. It equals 133 3224 pascal.

Millimetre of Water. A unit of pressure sometimes employed when a water Manometer is used to measure small pres-

ures, for example venous system pressures. One millimetre of water is equivalent to 9.8 pascal.

Mineralogy. The study of minerals (*i.e.* inorganic bodies produced in nature). It includes their mode of formation, the methods used in their discovery (*i.e.* prospecting), their chemical and physical properties, and their crystallography (macroscopic, microscopic, and sub-microscopic).

Minimum Deviation. Symbol D. The deviation produced by a transparent prism when light passes symmetrically through it. If A is the prism angle then the refractive index of the material of the prism equals

$$\sin[(A+D)/2]/\sin(A/2)$$

Minority Carrier. The type of carrier-either electrons of holes-responsible for transporting less than half the current in a Semiconductor.

Minor Planet. Another name for Asteroid.

Minute

1. A unit of time equal to 60 seconds.
2. Symbol: A unit of angle; 1/60 of a degree.

Mirage. An optical phenomenon that occurs as a result of the bending of light rays through layers of air having very large temperature gradients. An inferior mirage occurs when the ground surface is strongly heated and the air near the ground is much warmer that the air above. Light rays from the sky are strongly refracted upwards near the surface giving the appearance of a pool of water. A superior mariage occurs if the air close to the ground surface is much colder than the air above. Light is bent downwards from the object towards the viewer so that it appears to be elevated or floating in the air.

Mirror. A highly polished boundary between two optical media at which light is reflected. Generally the brightness of the reflection in increased by silvering or aluminizing the boundary surface.

Mirror Formula. The formula

$$l/v+l/u=l/f=2/r$$

where r is the radius of curvature of a spherical mirror, f its focal length and u and v respectively the object and image distances from the mirror. Distances to real objects and images are taken as positive, those to virtual objects and images and negative

Mirror Galvanometer. A galvanometer, the deflection of whose coil is determined from the deflection of a spot of light reflected from a mirror attached to the coil.

Mirror Image. A shape that is identical to another except that its structure is reversed as if viewed in a mirror, so that the two cannot be superimposed. For example, a left hand is the mirror image of a right hand.

Mirror Nuclei : Mirror Nuclides. Two atomic nuclei with the same number of nucleons, such that each nucleus has the same number of protons as the other has neutrons, *e g*. ${}^{8}_{4}$Li and ${}^{8}_{5}$B. Mirror nuclides with odd mass number in which the atomic number and neutron number differ by one, *e.g* , ${}^{3}_{1}$ and ${}^{3}_{2}$He, or ${}^{29}_{14}$Si and ${}^{21}_{95}$P, are known as Wigner nuclei.

Mixer : That portion of a receiver that performs frequency conversion. The input to the mixer consists of two signals – the modulated RF signal and the unmodulated local oscillator signal. The mixer then combines or mixes these two signals. As a result of this mixing action, the output of the mixer will contain four major frequencies, plus many minor frequencies. The four major frequencies are the original signal frequency, the local oscillator frequency, the sum of the signal and oscillator frequencies, and the difference of the signal and oscillator frequencies.

The addition frequencies present are produced by combinations of the fundamentals and harmonies of the signal and oscillator frequencies. Of the frequencies

present in the output of the mixer, only the difference frequency is used in amplitude-modulated broadcast band receivers. The output circuits of the mixer stage contains a tuned circuit that is resonated at the difference frequency.

Mixing Length. In the theory of the turbulent flow of a fluid : the distance through which small volumes of the fluid may be transported by turbulent motion before becoming mixed completely with their surroundings.

MKS Units. A system of units based on the metre as unit of length, the kilogramme a unit of mass and the second as unit of time, but differing from SI Units in the value of the Magnetic Constant : this is equal to 10^{-7} henry per metre in the MKS system. SI units have now replaced. MKS units.

MMF. For Magnetomotive Force.

MmHg (millimetre of mercury) A former unit of pressure defined as the pressure that will support a column of mercury one millimetre high under specified conditions. It is equal to 133.3224 Pa. It is equivalent to the torr.

Mobility. Of charge carriers moving in a solid, liquid or gas under the influence of an electric field : the drift velocity per unit electric field. The term may be qualified by other words to denote the nature of the carrier, as in ionic mobility.

Mobius Strip. A surface produced by twisting a band through 180° and then joining the ends together. It is mathematically interesting since it is a single surface with a single bounding curve.

Mock Sun : Parhelion. A luminous image of the Sun most frequently seen at an angular distance of about 22° from the Sun. The phenomenon is caused by refraction of the Sun's rays by ice crystals.

Modem : An electric device that performs the modulation and demodulation functions required for communications. A

modem can be used to connect computers and terminals over telephone circuits. On the transmission end, the modulator converts the signals to the correct codes for transmission over the communications lines. At the receiving end, the demodulator reconverts the signals for communication to the computer using the computer interface unit. A modem is also sometimes referred to as a data set.

Moderating Ratio. Of a moderator in a nuclear reactor : the ratio of the slowing down power to the thermal macroscopic absorption cross-section. It expresses the effectiveness of the moderator.

Moderator. Material used in the cores of some nuclear reactors to slow down fast-moving neutrons so that they will be more easily captured by fissile nuclei. The most effective speeds are about two thousand metres per second. Such neutrons are called thermal neutrons because the distribution of their speeds is such that they are in thermal equilibrium with (*i.e.* at the same temperature as) the surrounding materials. To achieve this slowing down in as few collisions as possible, moderators are substances of low atomic weight. Carbon, in the form of graphite, was used in early experimental reactors and is still used in Magnox reactors. Water—in some reactor designs, heavy water—is used and may also serve as the coolant. Paraffin wax and beryllium are also suitable moderators.

Modified X- Or γ-Ray Scatter. The incoherent component of the scattered when X- or γ rays interact with extranuclear electrons. Also known as Compton scatter.

Modulate. To change the characteristics of a high-frequency wave, such as its amplitude, frequency, or phase, by impressing one wave on another wave of constant properties. The wave that is produced is a composite of the modulation and the higher-frequency wave.

Modulation. The process of impressing one wave system, *i.e.* the signal, on another wave system, *i.e.* the carrier, so

that the information contained in the signal is transmitted by the carrier wave.

Modulus

1. The magnitude of a vector quantity.
2. The absolute value of a number or quantity. For example, the modulus of -4 is 4.
3. A ratio that defines some property of a material or of some other system.

Modulus of Decay. The quantity α^{-1} in the equation

$$a = a_0 e^{-\alpha t}$$

describing oscillations undergoing Damping: a_0 is the initial amplitude of the oscillation, a the amplitude at time t and α the damping factor.

Modulus of Elasticity. Another name for Elastic modulus.

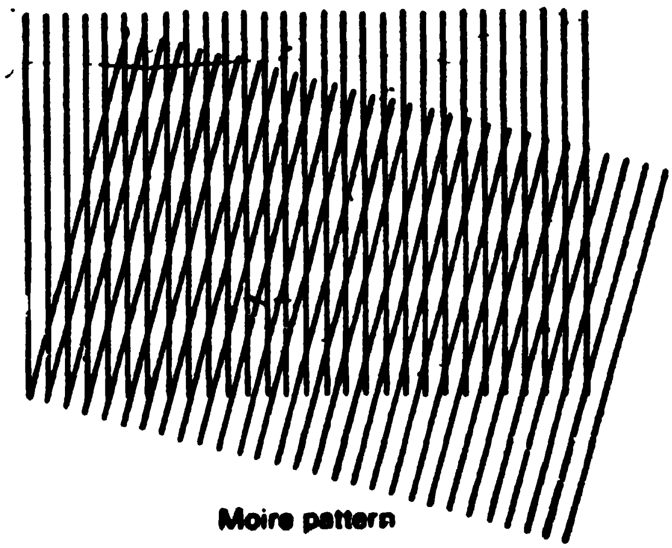
Modulus of Rigidity : Shear Modulus. Of an elastic body : the tangential force necessary to produce unit angular deformation.

Moho (Mohorovicic Discontinuity). A discontinuity within the earth that marks the junction between the crust and the underlying mantle. Below the discontinuity earthquake seismic waves undergo a sudden increase in velocity, a feature that was first observed in 1909 by the Yugoslavian geophysicist Andrija Mohorovicic (1857-1936), after whom the discontinuity was named. The Moho lies at a depth of about 10−12 km below the oceans and about 33−35 km below the continents.

Mohs' Scale. A hardness scale in which a series of ten minerals are arranged in order, each mineral listed being scratched by and therefore softer than those below it. The minerals are : (1) talc; (2) gypsum; (3) calcite; (4) fluorite; (5) apatite; (6) orthoclase; (7) quartz; (8) topaz; (9) corundum; (10) disamound. As a rough guide a mineral with a value up to 2.5 on this scale can be scratched by a fingernail, up to 4 can be scratched by a coin, and up to

6 by a knife. The scale was devised by Friedrich Mohs (1773-1839).

Moire Fringes. The pattern obtained when two regular sets of lines or points overlap. The effect can be seen through folds in curtain netting. Moire patterns can be used as models of interference patterns. Another application is in comparing two diffraction gratings by superimposing them and observing the moire pattern produced



Moire pattern

Molar

1. Denoting a physical quantity divided by the amount of substance. In almost all cases the amount of substance will be in moles. For example, volume (V) divided by the number of moles (n) is molar volume $V_m = V/n$.
2. A molar solution contains one mole of solute per cubic decimeter of solvent.

Molar Gas Constant. The value of R in the perfect gas equation

$$PV = RT$$

where P, V and T are respectively the pressure, volume and thermodynamic temperature one Mole of gas. The value of R is 8.314 joule per kelvin.

Molar Heat Capacity. The heat capacity of one Mole of a substance.

Molar Latent Heat. Latent heat.

Molar Polarization. The displacement of electrical centres which occurs when a molecule is subjected to an electric field and results in the production of a Dipole in the molecule. The ratio m/E is known as the polarizability of the molecule, where m is the dipole moment and E the magnitude of the electric field strength.

Molar Thermal Capacity. Symbol : C_m. The thermal capacity per unit amount of substance; *i e.*, the energy required raise unit amount of substance (1 mol) by unit temperature (1 K). It is measured in J mol^{-1} K^{-1}. For a gas, it is common to specify two principal molar thermal capacities : one measured at constant pressure and the other measured at constant volume. The relationship between them are as for specific thermal capacities.

Molar Volume (molecular volume). The volume occupied by a substance per unit amount of substance.

Mole. Symbol mol. The SI unit of amount of substance. It is equal to the amount of substance that contains as many elementary units as there are atoms in 0 012 kg of carbon —12. The elementary units may be atoms, molecules, ions, radicals, electrons, etc . and must be specified. 1 mole of a compound has a mass equal to its relative molecular mass expressed in grams.

Molecular Beam : Atomic Beam A narrowly defined stream of neutral molecules (atoms) moving through a highly evacuated enclosure, the distance between the molecules (atoms) both of the stream and of the surrounding space being so large that collisions or intermolecular (interatomic) forces can be neglected. Measurements with molecular and atomic beams have been used, among other things, for studying the kinetic properties of gases, the magnetic properties of atoms, molecules and nuclei, the hyperfine structure of spectra, and the interactions between gases and solids.

Molecular Compound. A compound consisting of two or more molecules held together by weak forces.

Molecular Crystal. A crystal in which individual molecules are held together by Van der Waals Forces.

Molecular Distillation. Distillation in high vacuum (about 0.1 pascal) with the condensing surface so close to the surface of the evaporating liquid travel to the condensing surface without collisions. This technique enables very much lower temperatures to be used than are used with distillation at atmospheric pressure and therefore heat-sensitive substances can be distilled. Oxidation of the distillate is also eliminated as there is no oxygen present.

Molecular Effusion : Molecular Flow. The passage of a gas through a fine tube or orifice under conditions such that the mean free path of its molecules is large compared to the internal dimensions of the tube or orifice.

Molecular Energy Levels. Energy levels corresponding to the various allowed states of rotation and vibration of the molecule.

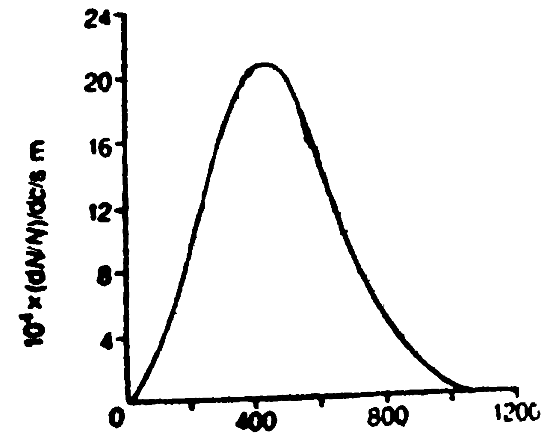
Molecular Flow (Knudsen flow) The flow of a gas through a pipe in which the mean free path of a gas molecules is large compared to the dimensions of the pipe. This occurs at low pressures; because most collisions are with the walls of the pipe rather than other gas molecules, the flow characteristics depend on the relative molecular mass of the gas rather than its viscosity. The effect was studied by M.H.C. Knudsen (1871-1949).

Molecular Spectrum. The absorption or emission spectrum that is characteristic of a molecule. Molecular spectra are usually band spectra.

Molecule. One of the fundamental units forming a chemical compound; the smallest part of a chemical compound that can take part in a chemical reaction. In most covalent compounds, molecules consist of groups of atoms held together by covalent or coordinate bonds. Covalent substances that form macromolecular crystals have no discrete

molecules (in a sense, the whole crystal is a molecule). Similarly, ionic compounds do not have single molecules, being collections of oppositely charged ions.

Molecular Speeds in Gas. Such speeds conform to a Maxwell-Boltzmann Distribution Law as illustrated in Fig. for nitrogen at 0°C. As the temperature is raised, the maximum of the curve occurs at progressively higher speeds.



Maxwell-Boltzmann distribution curve for molecular speeds

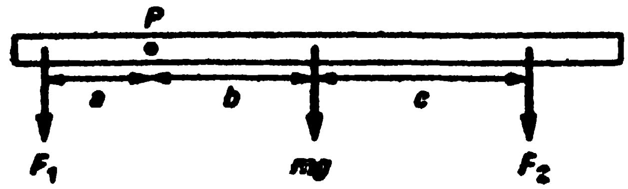
Molecular Volume. Molar volume.

Moment. The turning effect produced by a force about a point. If the point lies on the line of action of the force the moment of the force is zero. Otherwise it is the product of the force and the perpendicular distance from the point to the line of action of the force. If a number of forces are acting on a body, the resultant moment is the algebraic sum of all the individual moments. For a body in equilibrium, the sum of the clockwise moments is equal to the sum of the anticlockwise moments (this law is sometimes called the law of moments).

Moment, Magnetic. Magnetic moment.

Moment of a Force. A measure of the turning effect produced by a force about an axis. The magnitude of the moment is the product of the force and the perpendicular distance from the axis to the line of action of the force. An object

will be in rotational equilibrium if the algebraic sum of all the moments of the forces on it about any axis is zero.



Moment of a force. For equilibrium $mgb+F_2(b+c)=F_1a$, where mg is the weight of the beam acting through its centre of mass

Moment of Couple. The product of the magnitude of either of the forces constituting a Couple and the perpendicular distance between the lines of action of the forces.

Moment of Inertia. Symbol : I. The rotational analogue of mass. The moment of inertia of an object rotating about an axis is given by $I=\Sigma mr^2$, where m is the mass of an element distant r from the axis. Some important cases are listed in the table.

Moment of inertia. The value given is that for a perpendicular axis through the centre of mass

Object	Dimensions	Moment of inertia
thin rod	length l	$ml^2/12$
thin disc	radius r	$mr^2/2$
thin ring	radius r	mr^2
solid sphere	radius r	$2mr^2/5$

Moment of Momentum. Another name for Angular Momentum.

Momentum. The linear momentum (p) of a body is the product of its mass (m) and its velocity (v), *i.e.*, p=mv.

Momentum, Conservation of. Constant (linear) momentum (law of).

Momentum, Linear. Symbol : p. The product of an object's mass and velocity : p=mv. The object's momentum cannot change unless a net outside force acts. This relates to Newton's laws and to the definition of force. It also relates to the principle of constant momentum.

Momentum Space : Reciprocal Space. The space used in the band theory of solids. It is the same as that in which the reciprocal lattice is plotted.

Monatomic Composed of independent single atoms; thus helium, argon and other inert gases are monatomic.

Monitoring Pill. A microminiature Integrated Circuit or circuits incorporated in a pill. When swallowed by a patient the pill transmits information continuously on conditions in the patient's tracts. The transmission is monitored by an external receiver and is very useful in the diagnosis of conditions which would otherwise present diagnostic problems.

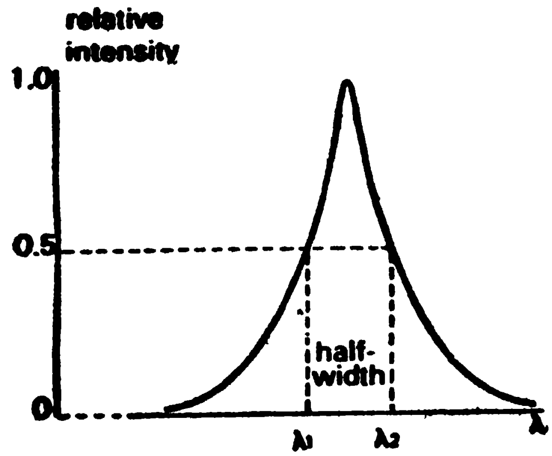
Monochord. A thin metal wire stretched horizontally over two bridges. The stretching force is applied by fixing the wire at one end, passing the other end over a pulley which is attached to the hollow box on which the sonometer is mounted, and then attaching weights to that end. The string may be set into vibration by stricking, bowing or plucking. Its length can be varied by adjusting the bridge positions. The hollow box acts as a sounding board, thus increasing the volume of sound resulting from the vibrations. The apparatus is useful for verifying the relationship between the length, diameter, tension and vibration frequency of a wire.

Monochromatic. Describes light, X-rays, or other radiation which consists of one wavelength only. In practice, the radiation so described usually consists of a narrow band of wavelengths.

Monochromatic Radiation. Electromagnetic radiation of an extremely narrow range of wavelengths. (The word means 'of one colour'). It is impossible to produce completely monochromatic radiation, although the output of some lasers is not far off. The 'lines' in line spectra produced even in the most ideal circumstances have some width in wavelength terms. The half-width is the measure used. It is the range of wavelengths defined in the figure, and contains almost 90% of the energy emitted. The half-

width of the sharpest lines currently obtainable is about 10^{-13} m.

Simple quantum theory leads one to expect perfectly sharp lines in a line spectrum—the energies of the levels concerned appear to be exactly defined, so that $\lambda = hc/\Delta E$. However, because of the uncertainty principle, no energy level or transition can be defined exactly: this means that any line is naturally broadened rather than being sharp. A second broadening influence is the Doppler effect, which is relevant as the radiating particles are always in motion. Thirdly, collisions between emitting particles will broaden the emitted line.



Monochromatic light

Monochromator. An instrument in which one narrow band of wavelengths is isolated from a beam of light or other radiation. This is usually achieved by means of a narrow-band interference filter, or by a diffraction grating or prism, together with an exit slit through which the desired waveband may pass. Changes in the intensity of the monochromatic beam can then be investigated.

Monolayer. A layer one atom or molecule thick.

Monolithic Circuit. An integrated circuit which uses either thin film or silicon chip techniques but not a mixture of both.

Monostable Circuit. An electronic circuit, usually a multivibrator, that has one stable state but can change to another state for a time after the application of a triggher pulse.

Monostable circuits can be used for generating single pulses of a fixed duration, for shortening or lengthening pulses, or to delay pulses in computer logic circuits. In a monostable multivibrator the input pulse is fed to the base terminal of one transistor (TR1) and through a resistor R to the collector terminal of the other (TR2). The base of TR2 and the collector of TR1 are connected through a capacitor C. The output voltage at the collection of TR2 is a pulse with a duration that depends on the values of R and C.

Monsoon. A seasonal wind which blows with regularity and constancy during one part of the year, and which is absent or blows from another direction during the remainder of the year. The most striking monsoons occur in Asia although similar wind changes do occur in Australia, Africa and the U.S.A. The term has also been applied to the wind regime above about 20 km, where there is a regular reversal of wind about the equinoxes in temperate latitudes.

Monte Carlo Method. A method of solving numerically problems arising in mathematics, physics and other sciences, by constructing for each problem a random process whose parameters are equal to the required quantities and on which observations can be made by ordinary computational means. From these observations, made on the random process, an estimate is made of the required parameters. In the probabilistic type of problem the actual random processes are simulated by suitably chosen random numbers and, from a sufficiently large number of observations using these numbers, the required information is obtained. Examples are investigations in neutron physics, problems of queueing and congestion, and the behaviour of epidemics. The deterministic type of problem is usally concerned with mathematical processes (*e.g.*, the solution of differential equations, the evaluation of definite integrals, and the inversion of matrices) which can be stated analytically but not always solved. A probabilistic problem is

then sought which has the same analytic expression as the one under investigation.

Monte Carlo Technique. A numerical method of solving scientific problems by constructing for each problem a random process whose parameters equal the required quantities and on which observations can be made by standard computational methods.

Month. The period of the moon's revolution around the earth with reference to some specified point in the sky (see table). The differences in the monthly periods result from the complicated motion of the moon.

Month	Reference point	Length (days)
tropical	equinox to equinox	27,321 58
sidereal	fixed star to fixed star	27,321 66
anomalistic	apse to apse	27,554 55
draconic	node to node	27,212 22
synodic	new moon to new moon	29,530 59

Moon. The Earth's only natural satellite, orbiting at a mean distance of 384 400 kilometre is approximately 29.5 day. The Moon's diameter is 3476 kilometre and its relative density 3.34. It has practically no atmosphere and is without surface water. The minimum night temperature is around 80 K and the maximum day temperature is about 400 K. The gravitational force due to the Moon markedly influences Tides on Earth. The Moon was first reached by man in 969.

Morning Star. A term normally applied to Venus when it shines brightly in the eastern sky before sunrise. Such periods last while Venus moves between inferior conjunction and superior conjunction and is located west of the sun. The term occasionally refers to spells of morning visibility of Mercury or other planets.

Morphotropic Series. A series of crystalline substances having similar crystalline structures (axial ratios and interfacial angles) which change progressively as one element or radical is replaced by another. Such a series is exemplified

by the sulphates of Li, Na, K, Rb, Cs, Ag, Tl and NH_4. A series of this kind is said to exhibit the property of morphotropy.

Morse Code. A system of dot and dash signals that is used in sending telegraph messages by wire. This code, devised by the inventor of the telegraph, Samuel F.B. Morse, uses the simplest signals to denote letters, numbers, and punctuation marks. The Morse code was used widely for many years for the transmission of all telegraph messages in the United States and Canada. Today, the code is still in use by some railroads, and for sending overseas telegraph messages by cable and in all wireless telegraph communication. Most telegraph messages sent today, however, originate from a teletypewriter, which is faster and provides a written copy of the message.

Morse Equation. The empirical equation

$$V_r = D(1 - \exp(-a(r - r_0)^2))$$

where V_r is the potential energy of a diatomic molecule for internuclear distance r, D is the dissociation energy of the molecule, r_0 is the equilibrium separation of the nuclei and a is a constant.

Morse Rule. An empirical relationship between the equilibrium internuclear distance, r_e, of a diatomic molecule and the equilibrium vibrational frequency, w_e. It states that $w_e r^3_e = 3000 \pm 120\ cm^{-1}$.

Mos. Abbrev. for metal-oxide Semiconductor.

Mosaic Electrode. The light-sensitive surface of a camera tube.

Mosaic Screen

1. A screen used for colour photography by the additive process. It consists of a minute pattern of red, green and blue filter elements.
2. The storage element in an electronic storage tube, or a television camera tube working on the storage principle.

Mosaic Structure. A type of imperfection exhibited by most crystals, the crystal containing mosaic blocks consisting of microcrystals misoriented relative to each other by a few minutes of arc, and being joined by dislocation arrays. Such a crystal is known as a mosaic crystal.

Moseley's Law. The frequencies of the lines in the X-ray spectra of the elements are related to the atomic numbers of the elements. If the square roots of the frequencies of corresponding lines of a set of elements are plotted against the atomic numbers a straight line is obtained. The law was discovered by H.G. Moseley (1887-1915).

Mosfet. A Field Effect Transistor employing MOS.

Mossbauer Effect. The emission without recoil of a gamma-ray photon from a nucleus embedded in a solid. The emission of a gamma ray by a single atom in a gas causes the atom to recoil and reduces the energy of the gamma ray from its usual transition energy E_0 to $E_0 - R$, where R is the recoil energy. In 1957 R.L. Mossbauer (1929-) discovered that if the emitting nucleus is held by strong forces in the lattice of a solid, the recoil energy is shared by all the nuclei in the lattice. As there may typically be 10^{10}-10^{20} atoms in the lattice the recoil will be negligible and the gamma-ray photon has the energy E_0. This effect is used in Mossbauer-effect spectroscopy to elucidate problems in nuclear physics, solid-state physics, and chemistry.

Motion. A change in the position of a body or system with respect to time, as measured by a particular observer in a particular frame of reference. Only relative motion can be measured; absolute motion is meaningless.

Motion in Straight Line. Linear Motion with or without constant Acceleration.

Motion, Newton Laws of

1. That every body continues in a state of rest or uniform motion unless acted upon by a force.
2. That the rate of change of momentum of a body in a given direction is proportional to the resultant force applied to it in that direction.

3. That to every action there is an equal and opposite reaction.

Motion of Projectile. Projectile Trajectory.

Motor. Any device for converting chemical energy or electrical energy into mechanical energy.

Motorboating. In an audio-amplifier system with two or more stages, a high-frequency howling or a low-frequency staccato noise. This effect is brought about when a small amount of signal fed back from the output to the input sets up self-oscillations in the amplifier, often by way of the supply voltage line that permits a common power supply voltage to be used by each stage of the amplifier. Motorboating can be prevented between stages by the use of decoupling filters. The time constant of a decoupling filter is typically of 0.005 to 0.02 s, which is usually large enough to give good filtering at the lowest frequency in the circuit.

Motor Generator. An electric motor mechanically coupled to an electric generator. The motor is driven by a supply of specified voltage, frequency, or number of phases and the generator provides an output in which one or more of these parameters is different to suit a particular purpose.

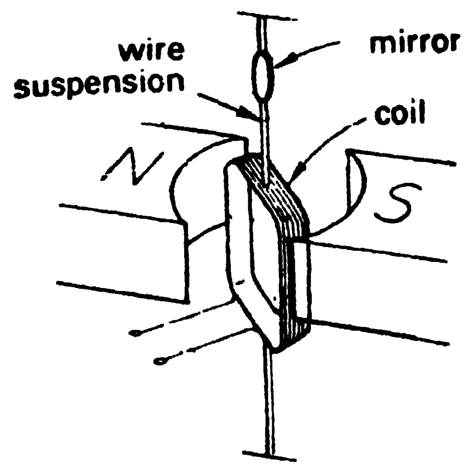
Mott Scattering Formula

1. A formula giving the differential cross-section for the mutual scattering of two identical charged particles at non-relativistic speeds.
2. A formula for the scattering of a fast electron by an idealized nucleus, obtained by the solution of the Dirac equation.

Moving-coil Instrument. An electric measuring instrument that depends on the force on a small vertical rectangular coil carrying direct current in a magnetic field. The coil has a fixed cylindrical soft-iron core and is suspended between the curved pole pieces of a strong permanent magnet, designed so that the field is radial. When a current flows the coil turns; it is stopped either by torsion in

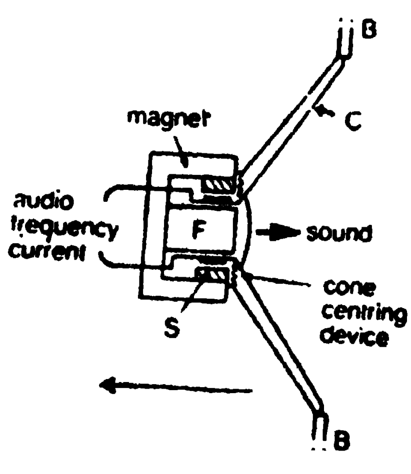
a suspending wire or by a spring. The angle turned is proportional to the current. In sensitive mirror galvanometers this is measured by a small mirror fixed to the torsion-wire suspension. In less sensitive ammeters and voltmeters a pointer is used.

The torque on the coil is equal to BIAN, where B is magnetic flux density, I current, A coil Area, and N the number of turns. The current depends on the angle of twist (θ) according to $I=k\theta/BAN$, where k is a constant of the spring or torsion wire.



Moving-coil instrument

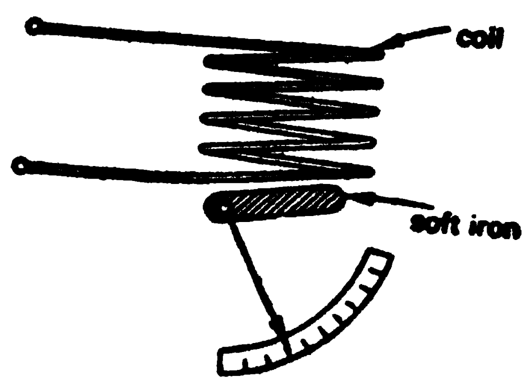
Moving-coil Loudspeaker. An instrument used to obtain sound energy from the electric energy produced by a microphone. As illustrated (Fig.), a speech coil S is wound on a cylin-



Moving-coil loudspeaker

drical former F positioned symmetrically in the radial magnetic field. Cardboard cone C is rigidly attached to F and loosely connected to a baffle board B. Current passed through S produces vibrations in it, thereby disturbing the large mass of air in C and thus producing a loud sound. The purpose of B is to reduce low-frequency interference affects.

Moving-iron Instrument. An electrical measuring instrument in which the current is passed through a fixed coil. The magnetic field produced attracts a piece of soft iron on a pivot. The iron is restrained by a spring and the movement detected by a pointer. Moving-iron instruments are less sensitive than moving-coil instruments, but can be used for alternating-currents without a rectifier (the attraction does not depend on the direction of current flow). The movement of the iron is roughly proportional to the square of the current.



Moving-iron instrument

Moving-iron Microphone. Microphone.

M Regions. On the Sun : restricted magnetically active regions which are responsible for geomagnetic disturbances by their emission of radiation, but not for magnetic storms.

Multielectrode Valve. A valve containing two or more sets of electrodes within a single envelope. Each set of electrodes has its own independent stream of electrons, but the sets may have one or more common electrodes, such as a common cathode.

Multimeter. An electrical measuring instrument designed to measure potential differences or currents over a number of ranges. It also usually has an internal dry cell to enable resistances to be measured. Most multimeters are moving-coil instruments with a switch to enable series resistors or parallel resistors to be incorporated into the circuit.

Multioutlet Assembly. A type of surface or flush raceway designed to hold conductors and receptacles assembled in the field or at the factory.

Multipactor Effect. A type of resonant discharge which occurs at high frequencies in a tenuous gas and leads to electrical breakdown in the gas.

Multiple-beam Interference. The interference of light beams reflected by a surface to reveal small variations in the flatness of the surface, *e.g.*, contours, cleavage steps, microscopic pits.

Multiple Reflection. A phenomenon occuring when two or more mirrors reflect the same beam of light several times in succession, resulting in the formation of a number of images.

Multiplet

1. A spectral line formed by more than two (doublet) closely spaced lines.
2. A group of elementary particles that are identical in all respects except that of electric charge.

Multiplex. The transmission of a number of different signals simultaneously over a single circuit. It is also a process of utilizing a single device for several similar purposes or using several devices for the same purpose. In working with digital electronic systems, a number of analog signals arriving from different sources may be multiplexed into a signal degital channel. Conversely, data from a singale digital channel may be taken and multiplexed into a number of analog channels.

Multiplication Factor. Symbol : k. In a nuclear chain reaction, the ratio of the rate of production of neutrons to the rate of 'loss' of neutrons (by absorption and leakage).

For subcritical reaction $k < 1$

For supercritical reactions $k > 1$

For critical reactions $k=1$

Multiplicity. The number of ways of vectorialls coupling the orbital and spin angular momentum vectors of an atom. It is represented by $2S+1$, where S is the total spin angular momentum quantum number. An even (odd) number of electrons leads to an odd (even) value of $2S+1$.

Multiplier. A device that generates a product from two numbers. A digital multiplier generates the product from two digital numbers bp addition of the multiplicand and in accordance with the value of the digits in the multiplier. It then shifts the multiplicand and adds it to the product if the multiplier digit is a 1 or shifts without adding if the digit is 0. This is done for each successive digit of the multiplier.

Multipolar. Denoting or having a Field Magnet with more than two poles.

Multipole Moments. The strengths of the equivalent multipoles (electric charge or monopole, electric or magnetic dipoles, quadrupoles, octupoles, etc.) which represent the effects, at points outside the system, of the electric and magnetic fields produced by a system of charges and currents, such as those arising from the electrons in an atom or from the protons in a nucleus; and which are assumed to be located at the centre of the system. The resultant field may be represented by an infinite series of terms, but where the series converges quickly only the first few of these need be considered. In atomic and nuclear physics the highest term of importance is the quadrupole term.

Multi-shock Compression. The deceleration to subsonic of the supersonic airflow in the intake of a supersonic aircaft engine or in the diffuser of a supersonic wind tunnel by a series of oblique shocks.

Multistable Circuit. An electronic circuit that has more than one stable state.

Multivibrator. An electronic oscillator consisting of two active devices, usually transistors interconnected in an electrical network. The purpose of the device is to generate a continuous square wave with which to store information in binary form in a logic circuit. This is achieved by applying a portion of the output voltage or current of each with the appropriate magnitude and polarity, so that the devices are conducting alternately for controllable periods.

Mu-meson. Former name for Mucon.

Muon. Symbol μ. A particle of mass 207 times that of the electron and of charge equal to the electron's. The muon is a Lepton. It is the analogue of the electron in the second Generation. It has a lifetime of 2×10^{-6} second and decays into an electron and neutrinos.

Musical Scale. An ordered stepwise series, arranged in order of frequency, of the sounds found in a musical composition or in the music of a people or period. The pattern of intervals (*i.e.*, frequency ratios between the various notes within an octave) repeats every octave. A large dumber of scales are or have beea in use, since any combination of intervals is theoretically possible, although certain intervals (*e.g.* the octave and the perfect fifth) are common in most.

Mutarotation Change of optical activity with time as a result of spontaneous chemical reaction.

Mutual Capacitance. The extent to which two capicitors can affect each other. It is expressed as the ratio of the amount of charge transferred to one to the corresponding potential difference of the other.

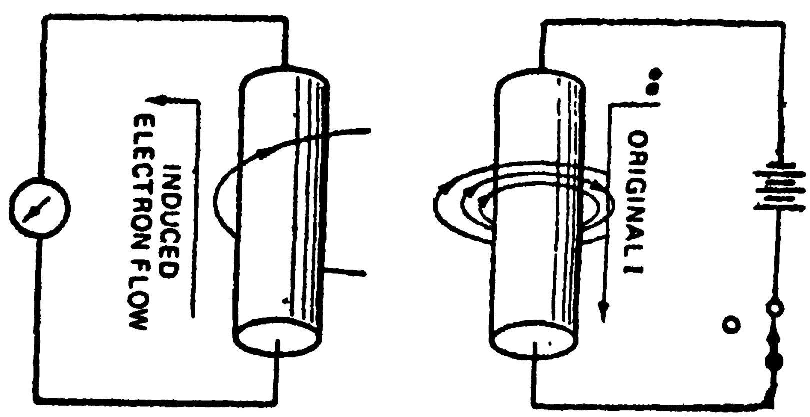
Mutual Inductance. Mutual induction.

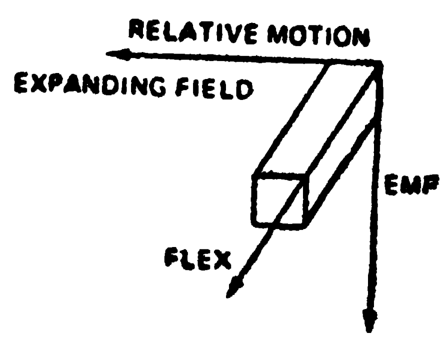
Mutual Induction. The ability of a circuit or device to transfer energy to another electrically isolated circuit or device. Faraday's and Lenz's laws express the concept involved in the process of mutual induction. Faraday discovered

that induced EMF was proportional to the rate of cutting of lines of force. Faraday also found that an EMF was induced only when there was a change in the flux linkages. Lenz's law states the same ideas in a more refined manner, but one fact is present in both cases. In order for there to be an induced EME or a transfer of energy, there must be a change of flux linkage.

Fig. illustrates the transferring of energy from a circuit containing a source to an electrically isolated circuit. When the switch is closed, there will be a momentary expansion of flux lines as the field builds up around the wire of the circuit on the left. These flux lines will cut across the conductor of the electrically isolated circuit on the right and produce a momentary EMF. If a steady state of current flow is reached, there will be no more expansion of the field and thus, no more flux lines will be cut.

Since no flux lines are being cut, there will be no CEMF produced. This does not mean the flux field has disappeard. It merrly means that as long as there is a





steady current flow in the source circuit (primary), the field will exist around the conductors of the primary and the isolated circuit (secondary), but there will be no relative motion.

In order to again induce energy in the secondary, there must be change in the field (flux linkage). This can be accomplished in one or two ways The current in the primary could be increased, causing the field to expand further. Additional flux lines would be cut as they passed through the secondary wire. All actions would be the same as the initial buildup of the field. The primary current could also be decreased (by operating the switch). Since there is no longer a current in the primary to sustain it, the field will collapse back ints the primary wire. In the process of collapsing, the flux lines will have to pass through the secondary wire, again producing a CEMF.

Myoneural Junction The Synapse between a nerve fibre and a muscle fibre. Transmission across such a junction produces an Action Potential in the musical fibre similar to but longer lasting and less confined than that in a Neutron.

Myopia. Short sight, normally, caused if the distance between the lens and the back of the eyeball is too long. Light from distance objects is focused at a point in front of the retina, and thus distant objects cannot be accommodated. Only close objects can be seen clearly. The problem may be corrected by use of diverging spectacle lenses.

Myriotic Field. A quantized field for which there are creation and annihilation operators satisfying specific commutation rules, but for which there is no vacuum state.

N

Nabla. Another name for Del.

Nadir. The point opposite the zenith on the celestial sphere.

Nand Circuit. A combination of an 'and' and a 'neither...nor' Logic Circuit.

Nano, Symbol n. A prefix used in the metric system to denote 10^{-9}. For example, 10^{-9} second=1 nanosecond (ns).

Narrow Beam. In beam attenuation measurements for ionizing radiation : a beam in which none of the scattered radiation reaches the detector.

Natural Abundances. Abundance.

Natural Convection The circulation of a gas or liquid due to difference in density resulting from temperature differences. A familiar example is the free movement of water contained in a nonforced water-heating system. Another example is the free movement of warm air throughout a room to provide heat.

Natural Dosage of Radiation. The radiation dosage due to cosmic rays, natural radioactive materials in soil and rocks and small amounts of radioisotopes, principally potassium.40, occurring naturally in the body. The total natural dosage per annum from all sources is 1.25×10^{-3} sievert : 0.5×10^{-3} sievert from cosmic rays and the same from the Earth and 0.25×13^{-3} sievert from potassium-40.

Natural Frequency. The frequency at which an object or system will vibrate freely. A free vibration occurs when there is no external periodic force and little resistance.

The amplitude of free vibrations must not be too great. For instance, a pendulum swinging with small swings under its own weight moves at its natural frequency. Normally, an object's natural frequency is its fundamental frequency.

Natural Gas A form of energy used by power plants to generate electricity. Natural gas varies widely in composition and contains many undersirable materials in its natural state. Some of these undesirables include water and sulfur compounds, all of which must be removed prior to transmission or use. Various chemical processes are used to refine natural gas. In this process, several by-products are produced and marketed, such as propane, butane, and elemental sulfur.

Natural Radioactivity. Radioactivity.

Nautical Mile. A measure of distance used at sea. In the UK it is defined as 6080 feet but the international definition is 1852 metres. 1 international nautical mile is therefore equivalent to 1.15078 land (statute) miles.

Near Infrared and Ultraviolet. The parts of the spectrum of electromagnetic radiation closest to the visible region. Near infrared emission and absorption are usually associated with transitions between vibrational energy levels of a molecule.

Near Point. The nearest point at which the human eye can focus an object. As the lens becomes harder with age, the extent to which accommodation can bring a near object into focus decreases. Therefore with advancing age the near point recedes—a condition known as presbyopia.

Near Sight. Another name for Myopia.

Near Ultraviolet. Near Infrared and Ultraviolet.

Nebula. Originally a fixed, extended, and somewhat fuzzy white haze observed in the sky with a telescope. The gaseous nebulae, however, cannot be resolved into individual stars and consist, for the most part, of interstellar dust and gas.

In some of these gaseous nebulae the gas atoms have been ionized by ultraviolet radiation from nearby stars and light is emitted as these ions interact with the free electrons in the gas. These are called emission nebulae. In the dark nebulae, there are no nearby stars and these objects are consequently dark; they can only be detected by what they obscure.

Nebular Hypothesis. Any of a group of theories based on the assumption that the solar system originated from the condensation of a nebula.

Neel Temperature : Neel Point. The temperature at which the susceptibility of an antiferromagnetic material has a maximum value. Only below this temperature does the ordered arrangement of magnetic moments exist which is characteristic of antiferromagnetism. It is sometimes termed the antiferromagnetic Curie point.

Negative Charge. Charge.

Negative Feedback. Feedback.

Negative Glow. In a glow discharge tube : a luminous region adjacent to the Faraday dark space on the cathode side.

Negative Lens. A lens with a negative power.

Negative Mirror. A mirror with a negative power.

Negative Pole. A south pole of a magnet.

Negative Principal Points. Another name for Antiprincipal Points.

Negative Proton. A synonym for antiproton.

Negative Resistance. The description of the negative slope of some voltage against current plots. Among devices showing this phenomenon are magnetrons, silicon controlled rectifiers and tunnel diodes.

Negative Specific Heat Capacity. The Specific Heat Capacity of a substance from which it is necessary to extract heat in order to raise its temperature. A saturated vapour is an example.

Negative Thermodynamic Temperature. A "temperature" of a nuclear spin system in a magnetic field at which a small increase in energy produces a decrease in entropy.

Negatron : Negation. A negatively charged electron.

Neon. Symbol Ne. A gas obtained from the atmosphere as a byproduct in the liquefaction of air. It is used in Neon Tubes and Fluorescent Lamps.

Neper. A logarithmic unit of attenuation used in electrical systems. If I_0 is the initial value of an electrical quantity (*e g.* power, current, voltage) and I is the final value, the expression $I=I_0e^{-N}$ signifies an attenuation of N nepers. The concept has been evtended to include scalar quantities in mechanics and acoustics. (Note : 1 neper=8.686 decibels.)

Nephelometry. The measurement of the cloudiness of a medium containing a suspension of small particles. Where the instruments employed determine the decrease in intensity of a transmitted light beam the process is termed turbidimetry. Where the scattered light is measured the term is Tyndallimetry.

Nephoscope. A meteorological instrument for the determination of the direction of motion and relative speed of clouds passing directly overhead.

Neptune. The outermost Giant Planet, distance 4.5×10^{9} kilometre from the Sun. Its diameter is 48 400 kilometre, its mass 17.2 times that of Earth, its orbital and axial rotation times 164.79 year and about 16 hour respectively. The temperature is around $-205°$ C and the atmosphere contains mainly methane and hydrogen.

Neptunium Series. The radioactive family of elements beginning with ^{237}Np and ending with ^{209}Bi (ordinary bismuth). Also known as the 4n+1 series (since the atomic number of each member of the series can be expressed in this way). ^{237}Np gives its name to the series since it is the most stable of the 4n+1 type nuclides above ^{209}Bi.

Nernst Calorimeter. An apparatus for determining the specific thermal capacity of a metal. A piece of the metal (mass m) is wound with a coil of insulated platinum wire and suspended in an evacuated container. Aluminium foil is wrapped around the coil to reduce radiation loss. A current (I) is passed through the coil at measured voltage V for a time (t). The coil is also used as a resistance thermometer (with the heating current off) to measure the temperature rise (θ) in the metal. Then

$$IVt=(mc+C\theta)$$

where c is the specific thermal capacity of the specimen and C the thermal capacity of the coil and foil (this is found by a separate measurement).

Nernst Effect. The development of a transverse electric potential across a conductor through which heat is flowing, when a magnetic field is applied at right angles to the direction of flow. The potential gradient, magnetic field and direction of heat flow are mutually perpendicular. The effect is analogous to the Hall effect.

Nernst Equation. An equation for electrode potential involving the osmotic pressure of the ions and the solution pressure of the electrode.

Nernst Glower. A rod composed of rare earth oxides which, when heated, is a useful source of infrared radiation.

Nernst Heat Theorem. A statement of the third law of thermodynamics in a restricted form : if a chemical change takes place between pure crystalline solids at absolute zero there is no change of entropy.

Nernst Lindemann Theory of Specific Heats. A modification of the Einstein theory in which the single frequency of atomic vibration is replaced by two frequencies, one of which is twice the other.

Nerve. A structure in the animal body whose special function is the transmission of information by electrical impulses. It consists of a bundle of nerve fibres enclosed in a sheath

and in each fibre is a conducting element (the axon), which is a threadlike protoplasmic outgrowth.

Net Radiometer. An instrument for measuring the difference in intensity between radiation striking and leaving the Earth's surface.

Network Analysis : Electrical Circuit Analysis. The use of mathematical techniques to predict the response of an electrical system to a given stimulus. By analogy the behaviour of non-electrical systems (*e g.*, acoustic, hydraulic, magnetic, mechanical) can also be treated by electrical circuit analysis.

Neumann Function. A Bessel function of the second kind.

Neumann's Law. The magnitude of an electromagnetically induced e.m.f. (E) is given by $E = -d\Phi/dt$, where Φ is the magnetic flux. This is a quantitative statement of Faraday's second law of electromagnetic induction and is sometimes known as the Faraday-Neumann law.

Neuron. A single nerve cell.

Neutral. Having neither negative nor positive net charge. This will be when the body is at earth potential.

Neutral Conductor. A grounded conductor in an electrical system that does not carry current until the system is unbalanced. Neutral conductors must have sufficient capacity for the current that they might have to carry under certain conditions. If, however, the loads on the outside wires become unequal, the difference in current flows over the neutral wire.

Where a 120/240-V single-phase service is used, it is highly desirable for the 120-V loads to be balanced across both sides of the service.

A general rule of thumb is to reduce the neutral by not more than two standard wire sizes. A further demand factor of 70 per cent may be applied in reducing the neutral wire for that portion of the unbalanced load that

is in excess of 200 A. However, if 50 per cent or more of the load consists of electric-discharge lamp ballasts, the neutral will be the same size as the ungrounded conductors.

In a three-phase, four-wire system, a three-wire branch circuit consisting of two phase wires and one neutral wire has a neutral or grounded wire that carries approximately the same current as the phase conductors. Motors and similar three-phase loads connected only to the phase wires cannot throw any load onto the neutral, and such three-phase loads can be disregarded in calculating the necessary capacity for the neutral conductor.

Neutral Current. Weak Interaction where no change occurs in the charges of the participants.

Neutral Equilibrium. Equilibrium such that if the system is disturbed a little, there is no tendency for it to move further nor to return.

Neutral Filter. A filter which absorbs radiation of all wavelengths equally, *i.e.*, it reduces the radiation intensity without changing the relative spectral distribution.

Neutralizing Capacitor. A capacitor usually employed in a radio receiving or transmitting circuit to neutralize a charge that has been placed across the capacitor plates. This is accomplished by feeding back a portion of the signal voltage equal to one-half of the total charge from the plate circuit to the grid circuit.

Neutral Point. A point where two fields in a region are equal and opposite, so that there is no resultant force. The situation is most often met in the case of magnetic fields. Thus magnetic neutral points are found near a permanent magnet in the Earth's field.

Neutral Surface. In elastic bending : a surface of zero stress.

Neutral Temperature. The temperature of the hot junction of a Thermocouple, the cold junction being at 0°C, for which the thermoelectric electromotive force is a maximum.

Neutretto. The neutrino associated with the muon.

Neutron. A neutral hadron (Elementary particles) that is stable in the atomic nucleus but decays into a proton, an electron, and an antineutrino with a mean life of 12 minutes outside the nucleus. Its rest mass is slightly greater than that of the proton, being $1.674\,92 \times 10^{-27}$ kg. Neutrons occur in all atomic nuclei except normal hydrogen. The neutron was first reported in 1932 by James Chadwick (1891-1974).

Neutron Capture. The capture of a neutron by an atomic nucleus. The most common form is radiative, *i.e.*, capture followed by the emission of γ-radiation, but α-particles, protons or neutrons may also be emitted.

Neutron Diffusion. The migration of neutrons from regions of high neutron density to those of low neutron density, in a medium in which neutron capture is small compared to neutron scattering. An approximate theory for such diffusion is based on the assumption that, in a homogeneous medium, the neutron current density is proportional to the gradient of the neutron flux density.

Neutron Energy Group. One of a set of groups consisting of neutrons having energies within arbitrarily chosen intervals. Each group may be assigned effective values for the characteristics of the neutrons within the group, and such groups form the basis of the multigroup theory of neutron transport.

Neutron Excess. Another name for Isotopic Number.

Neutron Flux Density. The product of the number of free neutrons per unit volume and their mean speed. In a Nuclear Reactor designed for power production, the neutron flux density is in the range 10^{16} to 10^{18} per metre squared per second.

Neutron Number. Symbol : N. The number of neutrons in the nucleus of an atom; *i.e.*, the nucleon number (A) minus the proton number (Z).

Neutron Hardening. The spectral hardening of neutrons.

Neutron Lifetime. The mean lifetime between production and absorption of a neutron in a given medium.

Neutron Multiplication. The production of neutrons in a medium containing fissionable material, as a consequence of a neutron chain reaction.

Neutron (Number) Density. The number of free neutrons per unit volume. Partial densities may be defined for neutrons characterized by such parameters as energy or direction.

Neutron Optics. The study of those aspects of neutron behaviour which are associated with wave properties, *e.g.*, diffraction, scattering, refraction, reflection, polarization.

Neutron Spectrometer. A device for isolating neutrons of some prescribed energy from a continuous spectrum of neutrons, for spectroscopic measurements.

Neutron Spectroscopy. The study of the variation of then umber of neutrons with neutron energy under specified conditions.

Neutron Star. A star composed chiefly of neutrons, whose density is comparable with that of an atomic nucleus, and whose existence has been postulated to account for the final stages of the life cycles of appropriately massive stars.

Neutron Temperature. A concept used to express the energies of neutrons that are in thermal equilibrium with their surroundings, assuming that they behave like a monatomic gas. The neutron temperature T, on the Kelvin scale, is given by $T=2E/3k$, where E is the neutron energy and k is the Boltzmann constant.

New Candle. Another name for Candela.

Newtonian Fluid. A fluid which obeys Newton's law of viscosity.

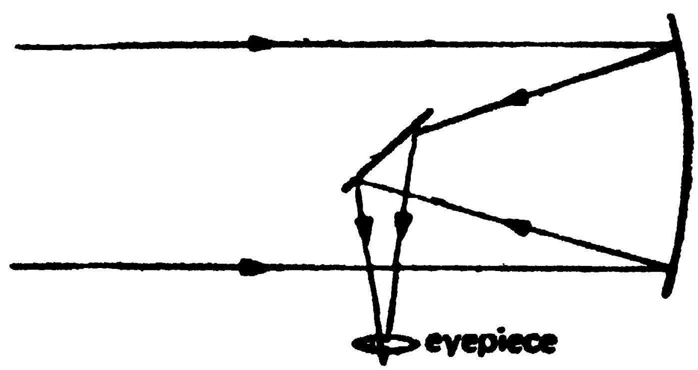
Newtonian Force. A force whose magnitude is inversely proportional to the square of the separation of the points between which the force acts.

Newton. Symbol N. The SI unit of force, being the force required to give a mass of one kilogram an acceleration of 1 m s^{-2}. It is named after Sir Isaac Newton (1642-1727).

Newtonian fluid

Newtonian Mechanics. The system of mechanics that relies on Newton's laws of motion. Newtonian mechanics is applicable to bodies moving at speeds relative to the observer that are small compared to the speed of light. Bodies moving at speeds comparable to the speed of light require an approach based on relativistic mechanics, in which the mass of a body changes with its speed.

Newtonian Telescope. A type of reflecting astronomical telescope, illustrated in Fig. Light from the object under observation is incident on the concave mirror and is then reflected into the eyepiece by a small plane mirror.



Newtonian telescope

Newton's Formula. For a lens, the distances p and q between two conjugate points is given by $pq=f^2$, where f is the focal length of the lens.

Newton's Law of Cooling. When a hot body is cooling in air, the rate of transfer of energy is proportional to the temperature difference between the body and its surroundings. This is strictly true only for forced convection.

Newton's Laws of Motion. Three laws of mechanics formulated by Sir Isaac Newton in 1687. They can be stated as :

1. An object continues in a state of rest or constant velocity unless acted on by an external force.
2. The resultant force acting on an object is proportional to the rate of change of momentum of the object, the change of momentum being in the same direction as the force.
3. If one object exerts a force on another then there is an equal and opposite force (reaction) on the first object exerted by the second.

The first law was discovered by Galileo, and is both a description of inertia and a definition of zero force. The second law provides a definition of force based on the inertial property of mass. The third law is equivalent to the law of conservation of linear momentum.

Newton Rings. Interference fringes, in the form of concentric rings, formed when a slightly convex lens is placed on a plane sheet of glass and the point of contact viewed by reflected light. Such rings may also occur whenever optical contact between two surfaces is not quite achieved.

Nichrome. Trade name for a group of nickel-chromium alloys used for wire in heating elements as they possess good resistance to oxidation and have a high resistivity. Typical is Nichrome V containing 80% nickel and 19.5% chromium, the balance consisting of manganese, silicon, and carbon.

Nickel-Iron Accumulator (Edison cell; NIFE cell). A secondary cell devised by Thomas Edison (1847-1931) having a positive plate of nickel oxide and a negative plate of iron both immersed in an electrolyte of potassium hydroxide. The reaction on discharge is

$$2NiOOH.H_2O+Fe \rightarrow 2Ni(OH)_2+Fe(OH)_2$$

the reverse occurring during charging. Each cell gives an e.m.f. of about 1.2 volts and produces about 100 kJ per kilogram during each discharge. Compare lead-acid accumulator.

Nife Cell. A type of accumulator consisting of a positive nickel and a negative iron plate dipping into sodium hydroxide solution.

Night Blindness. A condition associated with a shortage of Rhodopsin in the retinal rods of the eye. It is thought that vitamin A deficiency inhibits the ability to resynthesize rhodopsin which has been broken down by the action of light.

Nile (Nuclear Reactor Technology). A unit of reactivity numerically equal to 0.01. The smaller unit, the milli-nile, is more convenient for small changes in reactivity, and is the same as a p,c.m.

Nipkow Disk A mechanical scanning device used in early television. It consisted of a flat circular disk provided with a spiral of small holes. As the disk rotated across a field of view, tbe whole held was scanned upon each rotation.

Nit. Symbol : nt. A unit of luminance, equal to the luminance produced by one candela per square metre (cd m^{-2}).

NMR. Abbrev. for Nuclear Magnetic Resonance.

Noctilucent Clouds. Tenuous luminous clouds, at a height (about 80 km) far above that of ordinary clouds, that are visible only after sunset in a clear summer sky, when the Sun descends beyond about 6° below the horizon. They glow with a pearly silvery light, often showing a bluish tinge.

Nodal Line. A line joining the nodes (positions of minimum disturbance) in an interference pattern.

Nodal Points. Two points on the axis of a system of lenses; if the incident ray passes through one, the emergent ray will pass through the other.

Node. A point of minimum vibration in a stationary wave-pattern, as near the closed end of a resonating pipe. Compare antinode.

Nodical Month. The interval between successive passages of the Moon through a given node (*i.e.*, a point at which the plane of its orbit passes through the plane of the ecliptic). Its length is slightly more than 27.2 mean solar days. This month is also called the Draconitic month.

Noise

Any undesired sound. It is measured on a decibel scale ranging from the threshold of hearing (0 dB) to the threshold of pain (130 dB). Between these limits a whisper registers about 20 dB, heavy urban traffic about 90 dB, and a heavy hammer on steel plate about 110 dB. A high noise level (industrial or from over-amplified music, for example) can cause permanent hearing impairment.

2. Any unwanted disturbance within a useful frequency band in a communication channel.

Noise Factor. The ratio of the actual Noise at a circuit output to that at the input.

No-load Current. The current that flows through a device or circuit when the same device or circuit is delivering zero output current. For example, when the primary of a transformer is connected to an ac source, a voltage appears at the secondary winding even when it is not connected to a load. While there is no current flow from the output in this condition, a small amount of current flows in the primary winding to sustain transformer operation. Here, the no-load current is the measured drain from the primary input voltage source.

The same applies to amplifier circuits when their outputs are not connected to a load. A certain amount of input current is required to maintain operation. This is often known as idle current.

Non-attaching Gas. A gas in which electron attachment does not occur.

Nonconservative Force. A force such that the work done by it in returning an object to its starting piont by a closed path is not zero. The force applied in pushing an object round a closed path on a rough table is an example of a nonconservative force.

Non-crossing Rule. States that the potential energy curves of diatomic molecules which are of the same electronic species never cross.

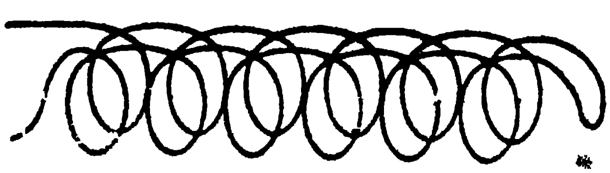
Nondegeneracy. The normal state of matter, *i.e.*, its state at moderate temperature and stress.

Non-diagram Lines. X-ray emission lines which arise from doubly or multiply-ionized atoms by a single electron jump, or by a two-electron jumb with one emitted quantum, and which do not therefore fit on the Moseley diagram.

Non-euclidean Geometry. Any logical self-consistent mathematical system concerned with shape but not based on the parallel postulate of Euclid (Euclidean Geometry). Non-euclidean geometry is used in Relativity theory.

Non-inductive Describing a circuit component that has a low inductance. Non-inductive coils are made by doubling back the wire on itself before making the coil. The current then flows in both senses through the coil and a negligible magnetic field is produced.

Noninductive Winding. A type of Winding, illustrated in fig. The winding turns back on itself so that any current induced in one half of the wiring will be equal but opposite to that induced in the other half. This is be-



Noninductive winding

cause the current follows the same path but in reverse directions in the two parts of the wire.

Nonlinear Acoustics. Acoustics.

Nonlinear Distortion. A combination of harmonic and amplitude Distortion in an electric signal.

Nonlinear Optics The study of the effects caused by very high intensity light beams. An example is the increase in the refractive index of glass in the path of an intense Laser beam; as a result the beam is narrowed and so its intensity and that of its associated electric field increase, sometimes to such a value that the glass is shattered.

Non-newtonian Fluid. A fluid that does not obey. Newton's law of viscosity.

Non-newtonian Liquids. Liquids which show a decrease in viscosity as their rate of flow or velocity gradient increases. Such liquids are said to exhibit anomalous viscosity.

Non-ohmic. Describing a substance or circuit component that does not obey Ohm's law; *i e.*, the current passed is not directly proportional to the potential difference across the circuit.

Nonohmic Resistance. A resistance which does not obey Ohm's Law. Semiconductor rectifiers are examples.

Normalizing Heat Treatment. The elimination of internal stresses in steel and the refinement of its crystal grains by heating above a specified temperature and subsequent cooling in air.

Nonreactive Of negligible Reactance.

Nonreactive Load. A load for which the alternating current is in phase with the terminal voltage.

Nonsaturated Mode. Saturated Mode.

Nonrelativistic Quantum Theory. Quantum theory.

Nonvortical Field. A vector field whose Curl is everywhere zero.

Normal. The perpendicular to a reflecting or refracting surface at the point of incidence of the ray concerned. Angles of incidence, reflection, and refraction are measured between the normal and the incident ray, reflected ray, and refracted ray respectively. A normal ray is one incident perpendicularly on a surface—the angle of incidence is zero.

Normal Adjustment. An image formed by an optical system is in normal adjustment if it is in a similar viewing position to the object. The term really refers to the adjustment of the system. Thus, normal adjustment of a telescope gives the image at infinity; normal adjustment of a microscope puts the image at the viewer's near point. Other adjustments are quite possible, and may be preferred in some cases.

Normal Boiling Point. The boiling point at a pressure of $1.013\ 25 \times 10^5$ pascal.

Normal Distribution. Another name for Gaussian Distribution.

Normal Force. The force between two bodies in contact in a direction perpendicular to the surface of contact.

Normalizing. The process of heating steel to above an appropriate critical temperature followed by cooling in still air. The process promotes the formation of a uniform internal structure and the elimination of internal stress.

Normalization. The introduction of a numerical factor into the equation $y=f(x)$ so that the area, if finite, under the corresponding graph becomes unity. The process is of importance in quantum mechanics and statistics.

Normal Melting Point. The melting point at a pressure of $1\ 013\ 25 \times 10^5$ pascal.

Normal Ray. Normal.

Normal Surface. One of a number of geometrical constructions for the determination of propagation velocities and vibration directions in doubly-refracting crystals. It shows the distribution of phase velocities.

Normal Temperature and Pressure (N.T.P.). Refers to a temperature of 0°C and a pressure of 760 mm of mercury. (*Note* : a pressure of 1 mm mercury is equal to 133.322 N/m^2).

Normal Vibration. An internal oscillation of a molecule in which all the atoms execute simple harmonic motion, move in phase and have the same vibration frequency.

North Polar Distance. Of a celestial body : is given by $90°-\delta$, where δ is the declination (the latitude of the body on the celestial sphere); and is counted as positive for north declinations and negative for south.

North Pole. Poles, magnetic.

Not Circuit. A basic Logic Circuit which inverts the input signal, *i e.*, binary 1 output (input) is associated with a binary 0 input (output).

Note

1. A musical sound of specified pitch.
2. A representation of such a sound in a musical score. Such a representation has a specified duration as well as a specified pitch.

Nova. A star that over a period of only a few days, becomes 10^3—10^4 times brighter than it was. Some 10—15 such events occur in the Milky Way each year. Novae are believed to be close binaries, one component of which is usually a white dwarf and the other a red giant. The outer envelope of the red giant engulfs the white dwarf and the two stars spiral together causing the subsequent nova explosion.

NPN Transistor. A bipolar transistor that is made from semiconductor materials that form an NPN junction. Three separate sections of semiconductor material are sandwiched together so that the P-type semiconductor lies between the N-type sections, as shown in fig. The emitter and collector of the transistor are attached respectively to the two N-type materials, while the transistor base lead is

connected to the P-type material. NPN transistors may be used to replace similar PNP types, as long as the circuit polarity is reversed.

NTP. Abbrev. for Normal Temperature and pressure.

N-type Conductivity. Semiconductor conductivity resulting from a flow of electrons.

N-type Semiconductor. An extrinsic Semiconductor for which the density of conduction electrons exceeds that of mobile holes.

Nuclear Astrophysics. The study of the contribution of nuclear reactions to the power output and total energy of individual stars.

Nuclear Barrier. A region of high potential energy through which a charged particle must pass in order to enter or leave an atomic nucleus.

Nuclear Battery. A single cell, or battery of cell, in which the energy of particles emitted from the atomic nucleus is converted internally into electrical energy. A typical cell delivers some 160 picoamperes at a voltage proportional to the load resistance. It can be used to maintain the voltage of a charged capacitor. Of greater use, especially in space technology, are the various types of low-voltage nuclear batteries. Typical is the gas-ionization device in which a beta-emitter ionizes a gas in a electric field. Each beta-particle produces about 200 ions thus multiplying the current. Other types use light from a phosphor receiving the beta particles to operate photocells or heat from the nuclear reaction to operate a thermopile.

Nuclear Charge. The charge on an atomic nucleus. It is equal to the product of the atomic number and the charge on the electron.

Nuclear Disintegration. The transformation of a nucleus, possibly a compound nucleus, involving a splitting into more nuclei or the emission of particles. If the disintegration is spontaneous it is said to be radioactive.

Nuclear Emulsion. A photographic emulsion capable of recording the passage through it (the tracks) of individual charged particles.

Nuclear Energy. Energy derived from nuclear reactions either by the fission of heavy nuclei into lighter ones or by fusion of light nuclei into heavier ones. Nuclear energy is exploited both for weapons construction and for civil power supplies. Both fission and fussion processes have been used in weaponry but, so far, it has not proved possible to exploit fusion processes for power production.

Nuclear Energy Change. Another name for Q Value.

Nuclear Energy Level. One of the energy values at which a nucleus can exist for an appreciable time ($>10^{-22}$s). The lowest level (the ground state) has a sharply defined value, but the others have a spread of values—the level width, which is inversely proportional to the mean life of the level. Partial widths may be assigned (*e.g.*, neutron width gamma width) which are proportional to the respective transition probabilities.

Nuclear Explosives. Bombs, missiles or other devices in which explosive power is derived from nuclear energy, *i.e.*, from nuclear fission or nuclear fussion.

Nuclear Ferromagnetism. Magnetism associated with dipole or exchange coupling between the spin of nucleons (spin-spin coupling). The spins tend to become parallel as in normal ferromagnetism, but the effect is much smaller.

Nuclear Fission. A nuclear reaction in which a heavy nucleus (such as uranium) splits into two parts (fission products), which subsequently emit either two or three neutrons, releasing a quantity of energy equivalent to the difference between the rest mass of the neutrons and the fission products and that of the original nucleus. Fission may occur spontaneously or as a result of irradiation by neutrons. For example, the fission of a uranium—235 nucleus by a slow neutron may proceed thus :

$$^{235}U+n \rightarrow {}^{148}La+{}^{85}Br+3n$$

The energy released is approximately 3×10^{-10} J per ^{235}U nucleus. For 1 kg of ^{235}U this is equivalent to 20,000 megawatt hours—the amount of energy produced by the combustion of 3×10^{6} tonnes of coal. Nuclear fission is the process used in nuclear reactors and atom bombs.

Nuclear Fission, Spontaneous. Nuclear fission which occurs without the need for the addition of particles or energy to the nucleus.

Nuclear Fission, Ternary. Nuclear fission in which three fragments of comparable mass are produced. It is extremely rare and the evidence for it is scanty.

Nuclear Fission Thermal. Nuclear fission caused by thermal neutrons.

Nuclear Force. A very strong short range attractive force acting between nucleons. Nuclear forces act over a range up to about 2×10^{-15} m and are much stronger than electromagnetic forces, so are able to overcome the electrostatic repulsion between protons in the nucleus. They are thus responsible for holding the nucleus together.

Nuclear Fuel. A substance that will sustain a fission chain reaciton so that it can be used as a source of nuclear energy. The fissible isotopes uranium—235, uranium—233 and plutonium—239 are the only ones known. The first occurs in nature as 1 part in 140 of natural uranium, the other two have to be made artificially. ^{233}U is produced when thorium—232 captures a neutron and ^{239}Pu is produced by neutron capture in ^{238}U. ^{232}Th and ^{238}U are called fertile isotopes.

Nuclear Fusion. A type of nuclear reaction in which atomic nuclei of low atomic number fuse to form a heavier nucleus with the release of large amounts of energy. These high kinetic energies imply temperatures of the order of 10^{8} K. As the kinetic energy required increases with the nuclear charge (*i e.* atomic number), reactions involving low atomic number nuclei are the easiest to produce. At these elevated temperatures, however, fusion

reactions are self-sustaining; the reactants at these temperatures are in the form of a plasma (*i.e.* nuclei and free electrons) with the nuclei possessing sufficient energy to overcome electrostatic repulsion forces. The fusion bomb (nuclear weapons) and the stars generate energy in this way. It is hoped that the method will be harnessed in the thermonuclear reactor as a source of energy for man's use.

Typical fusion reactions with the energy release in joules are :

$$D+D=T+p+6.4\times10^{-13}J$$
$$T+D={}^{4}He+n+28.2\times10^{-13}J$$
$${}^{6}Li+D=2\,{}^{4}He+35.8\times10^{-13}J$$

By comparison the formation of a water molecule from hydrogen and oxygen is accompanied by the release of 1.5×10^{-19} J.

Nuclear Heat of Reaction. Another name for Q Value.

Nuclear Induction. Another name for nuclear magnetic resonance.

Nuclear Magneton. The unit of nuclear magnetic moment, equal to

$$eh/(4\pi mc)$$

where e is the electronic charge, h the Planck constant, m the rest mass of the proton and c the speed of light. The value is

$$5.05\times10^{-27} \text{ joule per tesla.}$$

Nuclear Matter. The matter of which the atomic nucleus is composed. The term may also refer to matter of which the density is comparable with that of the nucleus, such as is believed to occur in some stars. A further use of the term in the legislation of some countries is to denote fissionable, radioactive, and similar materials.

Nuclear Medicine. The study of the use of radioisotopes in the diagnosis of disease, notably cancer. The radioacti-

vity can be measured in a variety of ways, for example using a Gamma Camera, Geiger Counter or Scintillation Counter. They thyroid, kidneys and liver are the main subjects of investigation by the method.

Nuclear Models. Descriptions of atomic nuclei based on a variety of simplifying assumptions. Many models have been proposed, all of which describe some phenomena but fail to account for others. The best known are :

(a) the liquid drop model, an early model now mainly of historical interest, in which nucleon motion was treated like that of molecules in a liquid;

(b) the shell, quasiatomic, independent particle or Hartree—Fock model, in which the motions of individual nucleons are assumed to be essentially uncorrelated with each other but occupy energy "shells" analogous to the electron shells in an atom, and which explains the observed "magic" numbers as shell closures;

(c) the unified model, which is a synthesis of the liquid drop and shell models;

(d) the Frami gas model, which is equivalent to the quasi-atomic model but assumes so many particles that surface effects are of secondary importance; and

(e) the generalized Hartree—Fock model, in which an "effective" internucleon potential is introduced to make some correlation between the motions of individual nucleons.

Nuclear Moment. A property of atomic nuclei in which lack of spherical symmetry of the nuclear charge gives rise to electric moments and the intrinsic spin and rotational motion of the component nucleons give rise to magnetic moments.

Nuclear Paramagnetism. The magnetism arising from nuclei with non-zero spin and hence having a magnetic dipole moment. An assembly of such nuclei is paramagnetic

but the paramagnetism is so small that it can be observed directly only in diamagnetic substances.

Nuclear Physics. The branch of physics that is concerned with nuclear structure, properties and reactions, and their applications (*e.g.* in producing nuclear power or using radioisotopes).

Nuclear Polarization. The tendency of nuclear spins to be aligned in a particular direction.

Nuclear Potential. The potential energy of some specified particle as a function of its distance from the nucleus.

Nuclear Potential Well. A pictorial description of the interaction between a nucleus and a nucleon (or a small group of nucleons as in a deutron or α-particle). The potential is constant and negative up to a certain distance from the nucleus, beyond which it is zero—hence the concept of a well.

Nuclear Power. The use of nuclear reactions for power generation (usually by generation of electricity but nuclear powered ships use the heat generated to raise steam to power the turbines directly without conversion to electricity). The reactions concerned are usually restricted to fission and fusion reactions; some people, however, include the use of energy from radioisotope decay.

Nuclear Power Station. A power station in which nuclear energy is converted into electric energy in a nuclear reactor. Compare Hydroelectric Power Station; Thermal Power Station.

Nuclear Quadrupole Resonance. The resonance interaction between a nuclear electric quadrupole moment and a molecular electric field gradient. Transitions between the associated energy levels give rise to nuclear quadrupole resonance spectra with frequencies 1—000 MHz.

Nuclear Radius. The distance from the centre of a nucleus at which the density of nuclear matter drops sharply. It is of the order

$$10^{-51} \times A^{1/3} \text{ metre}$$

where A is the Relative Atomic Mass of the nucleus.

Nuclear Reaction. Any reaction involving a change in the balance of the constituent nucleons of an atomic nucleus or in the energy state of the nucleus. If the Q-value is negative (*i e.* if there is a net loss of kinetic energy) the reaction is endoergic, and if the Q-value is positive it is exoergic.

Nuclear Reactor. An assembly in which a self-sustaining neutron Chain Reaction due to Fission can be maintained and controlled. Several types of fuel, moderator, coolant and cladding have been developed. Present-day main choices are shown in the table. The best choice for a particular purpose is a subject of debate.

Main choices for nuclear reactor

cladding	coolant	fuel	moderator
aluminium	carbon dioxide	natural uranium metal	graphite
magnesium alloy	helium	natural uranium dioxide	water
stainless steel	water	enriched uranium dioxide	heavy water
zirconium alloy	heavy water	enriched uranium carbide	
	liquid sodium	plutonium oxide	

Nuclear Reactor Blanket. A region of fertile material placed around or within a nuclear reactor core for the purpose of conversion. By extension the term may be used when the purpose is not conversion but the transformation of non-fertile material.

Nuclear Reactor Fuel. Material containing fissionable nuclides which, when placed in a nuclear reactor, enables a self-sustaining neutron chain reaction to be achieved. When the fuel is sealed in a can, or protected by the application of an external layer of material (cladding), it is known as a fuel element. A group of such elements which remains intact during the charging and discharging of a reactor with fuel is termed a fuel assembly.

Nuclear Reactor Oscillator. A device which produces periodic variations of reactivity by the oscillatory movement of a sample. It is used for measuring reactor properties, or nuclear cross-rections of the sample. The device was formerly known as a pile oscillator.

Nuclear Reactor Power Coefficient. The rate of change of the reactivity with respect to the thermal power of the reactor. In a homogeneous reactor it is the same as the temperature coefficient; but in a heterogeneous reactor the power and temperature coefficients are different, owing to the different temperatures of the various components.

Nuclear Reactor Power Density. The power generated per unit volume of a nuclear reactor core.

Nuclear Reactor Shield

1. *Biological shield* : material which reduces ionizing radiation in a given region to biologically permissible levels.
2. *Thermal shield* : material which prevents the biological shield from becoming overheated, by absorbing β-, γ- and X-rays the heat from which could otherwise damage that shield.

Nuclear Reactor Temperature Coefficient. The rate of change of the reactivity with respect to the temperature of the reactor. The coefficient may also refer to the temperature of some specified location or component of the reactor.

Nuclear Reactor Time Constant. The time required for the neutron flux density in the reactor to rise or fall by a factor *e*. It is also known as the reactor period.

Nuclear Reactor Types. Five main classifications exist: thermal, fast, breeder, power and research. A power reactor is designed for maximum power output whereas the main purposes of a research reactor are experimental. Most existing reactors are thermal, the type considered to be safest and easist to control; they do not however function as breeder reactors.

Nuclear Reactor Vessel. The principal vessel surrounding the reactor core.

Nuclear Recoil. The mechanical recoil suffered by a residual nucleus following the disintegration of a larger nucleus.

Nuclear Relaxation

1. *Nuclear spin lattice relaxation* : the process through which the nuclear spin system achieves thermal equilibrium with a crystal lattice.
2. *Nuclear spin-spin relaxation* : the tendency of an assembly of nuclei, initially processing in phase about a uniform magnetic field, to lose phase coherence.

Nuclear Resonance Energy. The kinetic energy of an incident particle (expressed in the laboratory system) that excites an energy level in a compound nucleus.

Nuclear Transition. Of a nuclide: a change in nuclear configuration. It may involve transformation to a different nuclide or a change in energy level accompanied by the emission of λ-rays. The latter is known as a radiative transition and has been termed electric or magnetic according as electric or magnetic multipoles are involved.

Nuclear Waste. Another name for Radioactive Waste.

Nuclear Weapon. An explosive device in which the reduction in mass that provides the thermal energy results either from the fission of heavy nuclei (such as ^{235}U) in a rapidly built up chain reaction or from the fusion of light nuclei such as deuterium and tritium to form helium. This latter type of device is known as a 'hydrogen bomb'. Although the total number of nucleons in the product is the same as in the original nuclei the mass of the resulting nucleus is less.

Nucleation and Growth. In recrystallization: a type of transition in which domains of new crystallographic orientation nucleate and grow at the expense of the parent crystals without accompanying changes in composition.

Nucleon. A particle found in the nucleus of atoms; *i.e.* a proton or a neutron. Nucleons are classified as baryons.

Nucleonics. The technological aspects of nuclear physics, including the design of nuclear reactors, devices to produce and detect radiation, and nuclear transport systems. It is also concerned with the technology of radioactive waste disposal and with radioisotopes.

Nucleon Number (mass number). Symbol : A The number of nucleons (protons plus neutrons) in an atomic nucleus.

Nucleons. Constituents of an atomic nucleus. A nucleon is either a proton or a neutron.

Nucleor. The hypothetical core of a nucleon, thought to be surrounded by a Pion cloud.

Nucleus. The most massive part of an atom, carrying a positive charge of Ze where Z is the Atomic Number of the element and e the magnitude of the charge on an electron.

The nucleus is held together by Strong Interaction and theories such as the Liquid Drop Model and the Shell Model have been proposed to explain nuclear structure. The mass of a nucleus is always less than the

sum of the rest masses of its constituent nucleons; the greater the Mass Defect, the more stable the nucleus (Binding Energy). The nuclei of most naturally occurring substances, other than radioactive ones, are stable. Artificial nuclei may result from the bombardment of stable nuclei with high-energy charged particles.

Nucleus, Atomic. The compact, comparatively massive, positively charged centre of an atom made up of one or more nucleons (protons and neutrons) around which is a cloud of electrons. The density of nuclei is about 10^{15}kg m^{-3}. The number of protons in the nucleus defines the element, being its atomic number (or proton number). The nucleon number, or atomic mass number, is the sum of the protons and neutrons. The simplest nucleus is that of a hydrogen atom, ^{1}H, being simply one proton (mass 1.67×10^{-27} kg). The most massive naturally occurring nucleus is ^{238}U of 92 protons and 146 protons (mass 4×10^{-25} kg, radius 9.54×10^{-15} m). Only certain combinations of protons and neutrons form stable nuclei. Others undergo spontaneous decay.

A nucleus is depicted by a symbol indicating nucleon number (mass number), proton number (atomic number), and element name. For example, ^{23}N a represents a nucleus of sodium having 11 protons and mass 23, hence there are $(23-11)=12$ neutrons.

Null Method. A method of making a measurement in which the quantity to be measured is balanced by another similar reading by adjusting the instrument to read zero.

Number of Poles. The number of different electrical conducting paths that a switching device closes or opens simultaneously.

Number System

1. A systematic method for representing numerical quantities in which any quantity is represented as the sequence of coefficients of the successive powers of a

particular base with an appropriate point. Each succeeding coefficient from right to left is associated with and usually multiplies the next higher power of the base. The first coefficient to the left of the point asscciated with the zero power of the base.

2. The following are names of the number systems with bases 2 through 20 : 2, binary; 3, ternary; 4, quaternary; 5, quinary : 6, senary 7, septenary : 8, octal or octonary; 9, nonvenary; 10; decimal; 11, undecimal; 12, duodecimal; 13, terdenary; 14, quaterdenary; 15, quindenary; 16, sexadecimal or hexadecimal; 17, septendecimal; 18 octodenary; 19, novemdenary; 20, vicenary.

Numerical Analysis. That branch of mathematical analysis which deals with the conversion of mathematical processes into operations with numbers. Its aim, typically, is to provide a method of computation that will give, in the most economical manner, numerical answers to a physical problem expressed in mathematical terms.

Numerical Aperture. Symbol NA. The quantity n sin i where n is the refractive index of the medium in which light strikes a microscope objective and i is half the angle subtended by the objective at the object. The greater the numercial aperture, the better the Resolving Power of the microscope.

Numerically-controlled Machine Tools. Machine tools in which information that automatically controls the position of the tool at each stage of the machining operation is fed to the machine in numerical form. The information is usually conveyed in the same way that numbers are fed into a digital computer, *i.e.*, by punched holes in paper tape, or magnetic signals on magnetic tape; but it can also be fed in manually.

Nusselt Number. A dimensionless quantity defined as $hl/(\lambda\theta)$ where h is the rate of loss of heat per unit area of a hot body immersed in material medium, the temperature

difference between body and medium being θ;l is a typical dimension of the body and λ thermal conductivity, of the medium.

Nutation. The oscillation of the axis of a rotating body about its mean position as in a spinning top or, more particularly, the axis of the Earth.

Nuvistor Tube. A triode that contains a cantilever-supported cylindrical electrode that eliminates the necessity of supplying mica supports. The nuvistor was created in response to the need for a high-vacuum device with increased frequency range to allow the use of the open-circuit approximation. This type of tube can withstand comparatively higher levels of shock and vibration and a much wider frequency range than its forerunners. These characteristics, along with its small size, make the nuvistor suitable for instrumentation equipment, communication systems, and audio and videoequipment.

Nyquist Formula. A formula for applying the theory of the Brownian motion to the problem of the "noise" in electrical networks that arises from the random movement of electrons.

Nyquist Noise Theorem. A theorem stating

$$dP/df = kT$$

where dP/df is the rate of change of power P, due to thermal noise, with frequency f at non extreme temperature T; k is the Boltzmann constant.

O

OASM System. A system of units based on the ohm, ampere, second and metre.

Object. A real or apparent source of rays in an optical system, perhaps incident on a lens or a reflector. After refraction or reflection, the rays appear to come from some other place—the image.

An object need not be real. The diagram shows how the real image I, produced by the lens, becomes a virtual object O_2 when the mirror is introduced. This now gives a real image I_2. Just as with real objects, virtual objects can appear as real or virtual images.

Objective (object lens). The lens or lens system in a refracting telescope that faces the observed object. The focal plane in which the image forms is termed the prime focus.

Objective Prism. A narrow-angle prism placed in front of the primary mirror or objective lens of a telescope. The prism disperses (dispersion) the incident light very slightly so that each star image is spread out into a small spectrum. The spectra of a field of stars can thus be recorded in a single photographic or electronic image and the chief spectral features of the stars can be quickly assessed.

Object Lens. Another name for Objective.

Object Plane. The plane perpendicular to the axis centred on the object.

Object Space. The space between Object and Objective.

Oblate. Denoting the Ellipsoid obtained by rotating an ellipse about its minor axis.

Oblique Ascension. Of a celestial body; the longitude of the body on the celestial sphere, measured eastwards from the first point of Aries (*i.e.*, the point at which the ecliptic crosses the celestial equator at the vernal equinox) along the ecliptic. It is also known as the celestial or ecliptic longitude.

Obliquity. The angle between the equatorial and orbital planes of a celestial body.

Observable. Signifying something measurable.

Obtuse Angle. An angle lying between 90° and 180°.

Occlusion

1. The trapping of small pockets of liquid in a crystal during crystallization.
2. The absorption of a gas by a solid such that atoms or molecules of the gas occupy interstitial positions in the solid lattice. Palladium, for example, can occlude hydrogen.

Occultation. Complete or partial obscuration of an astronomical object by another of larger apparent diameter, especially the moon or a planet. A solar eclipse is strictly an occultation. The precise timings of occultations provide information about planetary atmospheres, the dimensions of extended visible, radio, and x-ray objects, and the positions of objects, such as distant radio sources.

Oceanography. The study of the hydrodynamics of the ocean, and the evolution and structure of the ocean basin.

Octave. The interval between a waveform and another of twice the frequency. An octave in sound corresponds to eight notes on the diatonic musical scale.

Ocular. Another name for Eyepiece.

Odd-even Nucleus. An atomic nucleus containing an odd number of protons and an even number of neutrons.

Odd-odd Nucleus. An atomic nucleus containing odd numbers of both protons and neutrons. Most such nuclei are unstable.

Odd-order Harmonic. A signal in a complex waveform that is an odd multiple of the fundamental frequency.

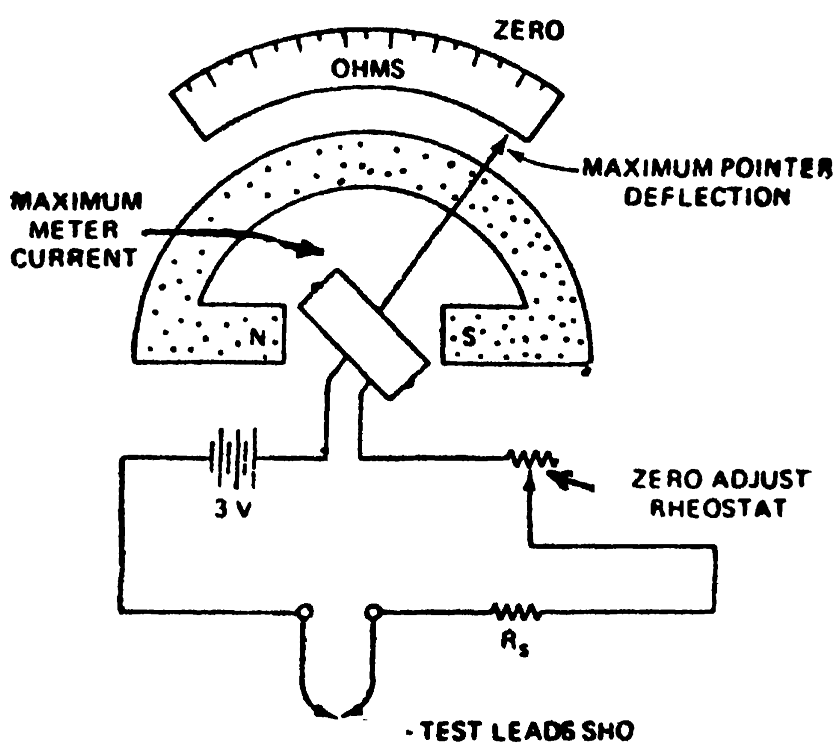
Oersted. Symbol : Oe. A unit of magnetic field strength in the c.g.s. system. It is equal to $10^3/4\pi$ A m^{-1}.

Off-frequency. A term used to describe the operation of a radio transmitter or receiver in relationship to a desired assigned or indicated frequency. If a transmitter frequency indicator reads 7 MHz while the externally measured output is known to be 7.5 MHz, then the indicator is off-frequency by 0.5 MHz.

Ohmic. Denoting a resistance or other electric device which obeys Ohm's Law.

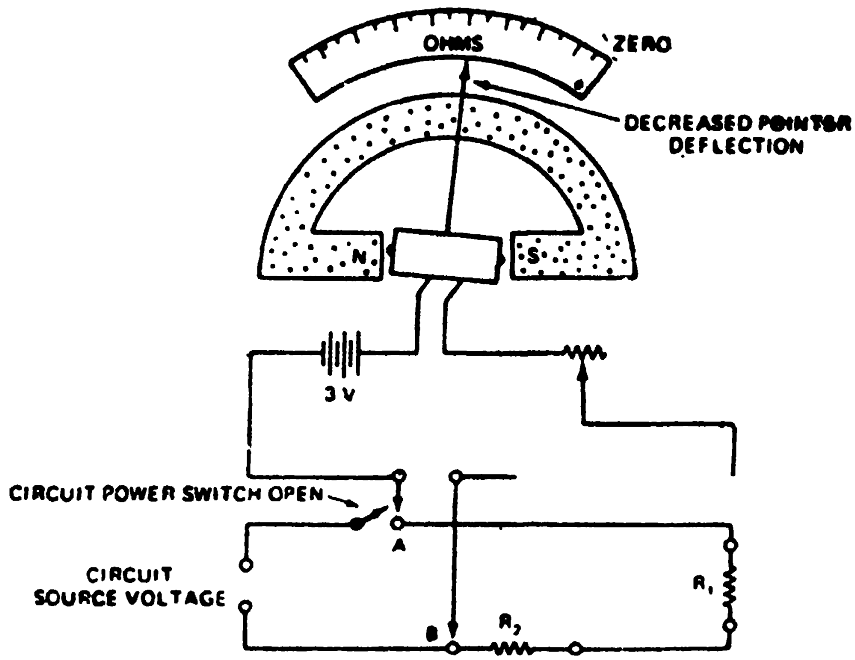
Ohmic Loss. The power dissipation in an electric circuit due to resistance.

Ohmmeter. Any direct-reading instrument for measuring the value of a resistance in ohms. The instrument commonly used is a multimeter capable of measuring also both currents and voltages. To measure resistance a dry cell



Simple ohmmeter circuit

and resistor are switched in series with the moving coil galvanometer and the unknown resistance is connected across the instrument's terminals. The value of the resistance is then read off an ohms scale. Such instruments are increasingly being replaced by electronic digital multimeters.



Measuring circuit resistance with an ohmmeter

Ohm's Law. That law that states that if a voltage of 1 V applied across a resistance causes a current of 1 A through the resistance, the resistance is 1 Ω. This relationship between amperes, ohms, and volts is one of the most important basic electrical laws, because its application helps to solve more different kinds of electrical problems than any other one rule or law.

Ohm's law states that the current in amperes increases and decreases directly with the increase or the decrease of the pressure difference in volts In other words, the current increases proportionately with every decrease in resistance, and the current decreases proportionately with any increase in resistance, provided the voltage remains the same throughout.

Oil-drop Experiment. The experiment, carried out by Millikan, by which the charge on the electron was determined for

the first time. It was based on the measurement of the rate of fall of a charged oil drop in an electric field.

Oil-filled Capacitor. A paper capacitor that has been immersed in oil. They are often used in radio transmitters where high output power is desired. The oil-impregnated paper has a high dielectric constant, which lends itself well to the production of capacitors that have a high value. Many capacitors will use oil with another dielectric material to prevent arcing between the plates. If an arc should occur between the plates of an oil-filled capacitor, the oil will tend to reseal the hole caused by the arc. These types are often called self-healing capacitors.

Oil-immersion Lens. Immersion objective.

Oil Immersion Objective. An objective used in a Microscope in order to increase the Numerical Aperture. A few drops of cedar wood oil are placed on the upper slide covering the object and the objective lowered so that its lower surface is immersed in the oil. By suitable choice of object distance, Spherical Aberration due to the objective can be reduced.

Oil Sight. Another name for Presbyopia.

Omega Minus Particle. Symbol Ω^-. A negatively charged elementary particle with a mass 3276 times that of the electron. It is classified as a Hyperon.

One-group Theory. A theory of neutron transport in which it is assumed that all the neutrons belong to the same energy group.

Onsager Reciprocity Theorem. A theorem concerning the behaviour of unbalanced systems. It includes, but is not limited to, the behaviour of thermodynamic irreversible systems.

Opalescence

1. The interference colours observed with certain minerals such as opal, which arise from the existence of very thin surface films.

2. The iridescent appearance of a solution arising from the reflection of light from suspended particles.

Opaque. Not able to pass radiant energy. A substance that is opaque to one type of electromagnetic radiation may be transparent to another. Thus glass passes visible radiation very well, but is opaque to most thermal (infrared) radiation. Compare translucent.

Opaque Projector (episcope). An optical instrument for projecting an image of an opaque object (*e g*., a diagram or picture) onto a screen. High-intensity illumination is used and the image is projected by a combination of mirrors and lenses.

Open Circuit. One which does not provide a complete pato for an electric current.

Open Cluster. A diffuse group of between 20 and a few hundred stars that move through the Milky Way together. About 1000 such clusters are known; some of them closely resemble globular clusters although they are less tightly bound and disperse more easily (as a result of rotation of parts of the Galaxy and the effects of interstellar dust clouds).

Open Pipe. Vibrations in Pipes.

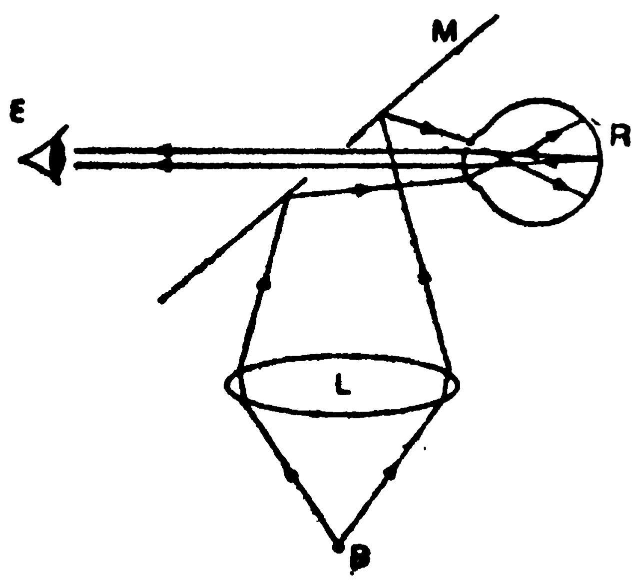
Opera Glass. Binoculars in which two Galilean telescopes are employed, with correspondingly small magnifications. No real image is formed so that the image is not inverted and no prism system is required to produce an erect image.

Operating Point. The point on the Characteristic Curve for a Transistor or Valve representing the voltage and current for the operating conditions being used.

Operational Amplifier. A very high-gain differential amplifier that provides a stabilized voltage gain by using voltage feedback. It is basically a differential amplifier, which has a very high open-loop gain in addition to high-input impedance and low-output impedance. Operational amplifiers are generally used for scale changing, in analog

computer operations, and in many phase shift, oscillator, and instrumentational circuits.

Ophthalmoscope. A portable instrument for viewing the retina of the Eye; the usual form is shown in Fig. A battery operated light source B together with a lens L whose position can be adjusted are contained in a handle supporting the plane mirror M, through a hole at whose centre observations are made. As shown, the subject's retina R is illuminated by an unfocused diverging light beam. Light scattered from the retina of a normal relaxed eye emerges from the eye as a parallel beam, which is focused by E, the observer's relaxed eye. To correct for any deviations from normal refraction by the subject's eye, provision is made for introducing a suitable correcting lens behind the hole in the mirror; a clear view of the subject's retina can thus always be obtained.



Ophthalmoscope

Oppenheimer-phillips Process. A reaction in which a low-energy deuteron gives its neutron to a nucleus without entering it.

Opposition. Of a celestial body : the instant when the body is in line with the Earth and the Sun.

Optic-acoustic Effect : Tyndall-roentgen Effect. The production of periodic pressure fluctuations and sound emission from

a radiation-absorbing gas or vapour exposed to periodically interrupted thermal radiation. It arises from the successive heating and cooling of the gas or vapour.

Optical Axis. The imaginary line passing through the midpoint of a lens, mirror, or system of such elements and on which lies the focal point of parallel paraxial rays.

Optical Bench. A track on which optical components can be mounted and moved. It is used extensively in optics experiments.

Optical Centre. The point at the geometrical centre of a lens through which a ray of light entering the lens passes without deviation.

Optical Character Recognition. A technique of feeding conventional printed characters into a computer. A special typeface is usually necessary.

Optical Constants. The refractive index, n, and the absorption coefficient, α, which together determine the complex refractive index $n-i\alpha$ of an absorbing medium.

Optical Crown. Any of various types of low Dispersion optical glass.

Optical Defects of Eye. Myopia; Hypermetropia; Presbyopia; Astigmatism.

Optical Density. For light transmitted by an absorbing medium the optical density is defined as $\log_{10} I_0/I$, where I_0 is the incident and I the transmitted intensity. It is synonymous with the optical extinction. For partly scattering media such as photographic negatives terms such as specular or diffuse density are used to explain how I and I_0 are measured.

Optical Depth. Symbol : τ. A measure of the absorption of radiation of a particular wavelength as it passes through a gaseous medium. If the initial radiation flux Φ_0 is reduced to Φ_x after a distance x through the medium then

$$\Phi_x/\Phi_0=\exp(-\tau)$$

where τ is the optical depth for the radiation wavelength. If τ equals zero the medium is transparent; if τ is much greater or much less than one the medium is optically thick or optically thin respectively.

Optical Distance. Another name for Optical Path.

Optical Distortion. Distortion.

Optical Fibre. A waveguide through which light can be transmitted with very little leakage through the sidewalls. This structure enables a beam of light to travel through many kilometres of fibre. In the graded-index fibre, each layer of glass, from the fibre axis to its outer wall, has a slightly lower refractive index than the layer inside it. This arrangement also prevents light from escaping through the fibre walls by a combination of refraction and total internal reflection, and can be made to give the same transit time for rays at different angles.

Fibre-optic systems use optical fibres to transmit information, in the form of coded pulses or fragmented images (using bundles of fibres), from a source to a receiver. Over moderate distances they are used in telecommunications, for which purpose they are becoming competitive with electric cables. They are also used in medical instruments (fibrescopes) to examine internal body cavities, such as the stomach and bladder.

Optical Flat. A surface used in engineering metrology for the measurement of the flatness of lapped surfaces, etc. It consists of a plate of glass, fused silica or quartz with one or both surfaces worked and polished flat to within about 10^{-6} cm. The parallelism between the faces, where two faces are involved, is of the same order of accuracy.

Optical Flint. Any of various types of high Dispersion optical glass.

Optical Glass. A type of glass with properties suitable for making lenses, prisms, etc. There are two major groups: the crown glasses and the flint glasses, differing in their

density and refractive constants. Optical glasses are fairly hard yet easily polished and highly transparent to light.

Optical Information Processing. The function performed by any system which processes data in a parallel rather than a serial fashion, and which uses light at some stage as a carrier of the data. The initial data may be in the form of light or a transformation into light may take place later. A simple example of a parallel system is a photographic transparency. Two of these systems may be multiplied by superposing them and illuminating them by a suitably collimated beam, the transmitted intensity distribution then containing the required data for a set of parallel products.

Optical Instrument. Any device, incorporating optical components, which improves seeing.

Optical Isomerism. The phenomenon exhibited by substances whose physical properties, apart from Optical Activity, are identical. The phenomenon is very common in substances which contain asymmetric carbon atoms, for example the two forms of lactic acid, for which the molecular structure of one isomer is the mirror image of the other.

Optical Isomers. Optical activity.

Optical Lever. A device for measuring angular displacement. A small mirror is attached to the rotating body and a narrow fixed beam of light directed onto it. The reflected beam is directed onto a screen, producing a spot of light. Movement of this spot shows small angular movements of the mirror. The angle turned through by the reflected beam is twice that turned by the mirror. The device is commonly used in torsion balances, as in the mirror galvanometer.

Optical Maser. Another name for Laser.

Optical Microscope. Microscope.

Optical Model of Particle Scattering. An optical analogy designed to describe the interaction of incident particles

with nuclei. The nucleus is considered as a semitransparent sphere with a refractive index and absorption coefficient. The refracted and incident waves then interfere to produce the phenomena observed experimentally. The usual (real) nuclear potential well is replaced by a complex one.

Optical Path. Symbol : d. The product of distance (l) travelled in a medium and the refractive constant (n) of the medium; *i.e.* d= nl. Phase difference ($\Delta\phi$) relates to path differene (Δd) thus :

$$\Delta\phi=2\pi\Delta d/\lambda$$

Optical Pathlength. The distance, d, travelled by a light beam multiplied by the refractive index, n, of the medium through which the light has passed. If the light traverses more than one medium, then the optical pathlength is the sum

$$(n_1d_1+n_2d_2+\ldots)$$

for each medium. It gives the effective pathlength in terms of wavelength of light.

Optical Pumping. The process of using optical radiation to excite phase-coherent radiation by the maser action.

Optical Pyrometer (disappearing-filament pyrometer). A type of pyrometer used to measure the temperature of incandescent sources. Light from the source is focused onto a tungsten filament, and the filament and the image of the source are viewed through a red filter and an eyepiece. The current in the filament is varied until this has the same brightness as the body (*i.e.* it cannot be seen against the background of the source). The ammeter is calibrated directly in degrees Celsius, with the assumption that the source emits blackbody radiation. A correction can be made for the spectral emissivity of the source.

Optical Rotary Dispersion (ORD). The phenomenon in which the amount of rotation of plane-polarized light of an optically active substance depends on the wavelength Plots of rotation against wavelength can be used to give information on molecular structure.

Optical Rotation. The rotation of the plane of polarization of a beam of light by an optically active substance.

Optical Rotatory Dispersion. A plot of Optical Activity, as measured by the specific optical rotary power, against wavelength. It yields information on molecular structure.

Optical Telescope. A telescope using visible light from a distant object to produce a magnified image.

Optical Temperature. Radiation temperature.

Optical Test Plate. A polished master gauge which is used to determine the accuracy of an optically polished surface by measurement of the interference fringes between the test plate and the surface.

Optical Thickness. Of a given thickness of a transparent medium : the distance that light would travel in a vacuum in the same time that it takes to travel through the given thickness of the medium. It is the geometrical thickness of the medium multiplied by the refractive index, and is also known as optical depth and optical distance.

Optical Wavelengths. Wavelengths in the visible region of the spectrum, ranging from about 380 to 750 nanometres.

Optical Wedge. A wedge-shaped neutral density filter.

Optic Axis. The direction in a birefringent crystal along which the ordinary and extraordinary rays travel at the same speed. Uniaxial crystals have one such axis; biaxial crystals have two.

Optical Window. Atmospheric Windows.

Optic Axis. Optical Axis.

Optic Nerve. The nerve bundle responsible for transmitting electic signals generated in the rods and cones of the retina to the brain.

Optics. The study of the nature and behaviour of light and other radiations. The reflection of ultraviolet radiation and the refraction of sound (pressure) waves also

follow the laws of optics. Electron diffraction and the electron microscope are branches of electron optics.

Where the wave nature of the radiation need not be considered, situations can be discussed in terms of rays. That study is traditionally called geometrical optics. Physical optics is the field of optics in which wave properties are important. Thus the use of lenses is part of geometrical optics, while the diffraction grating comes into physical optics.

Optoelectronics. An area of electronics that deals with photo-electricity, lasers, and the amplification of light waves. Optoelectric devices normally consist of a light source that is used to trigger a phototransistor, Lascr, light-activated triac, etc. The light source is triggered by current flow in one circuit, while the light-receiver component controls another circuit or simply switches it on or off.

For example, optoelectronic couplers are used to control high-voltage circuits that are connected to the light receiver by means of a low-voltage, low-current source that drives the light source. Both the source and the receiver are located in a single package, and a very high degree of electrical isolation of the two circuits is derived because there is no dc connection between the two.

Optoisolator. An optoelectronic device produced from the combination of an Led and a phototransistor. It allows the transfer of signals from one circuit to another with complete electrical isolation, and an insulation resistance measured in kilovolts between the Led and the phototransistor is usually guaranteed.

Orbit. The path followed by a celestial object or an artificial satellite or spaceprobe that is moving in a gravitational field. For a single object moving freely in the gravitational field of a massive body the orbit is a conic section, in actuality either elliptical or hyperbolic. Closed

(repeated) orbits ard elliptical, most planetary orbits being almost circular. A hyperbolic orbit results in the object escaping from the vicinity of a massive body.•

Orbital

1. Pertaining to an orbit. For example, an orbital electron is one that is bonded around the nucleus of an atom.

2. According to quantum theory, the electrons in an atom do not have fixed orbits around the nucleus. Instead, there is a finite probability of finding the electron in a given volume at any distance from the nucleus. The region in space in which there is a high probability of finding an electron is an atomic orbital. For a hydrogen atom in its ground state the orbital is a spherical shell around the nucleus. Other types of orbital have different shapes. Similarly, in molecules, electrons move in molecular orbitals around the nuclei of the atoms.

Orbital Angular Momentum. The angular momentum of a particle or system of particles that revolves in an orbit (or behaves as though it did). It is expressed in units of $\hbar$, *i,e.*, $h/2\pi$.

Orbital Velocity. The velocity of a satellite or other orbiting body at any given point in its orbit. It is also the velocity required by a satellite to enter an orbit around a body. The orbital velocity, v, is given by the expression

$$v=\sqrt{[gR^2(2/r-1/a)]}$$

where R is the radius of the orbited body, r is the distance from the centre of mass of the system (*i.e.*, from the approximate centre of the primary), a is the semi-major axis of the orbit, and g is the standard acceleration of gravity. For a circular orbit, r=a and the circular velocity is given by

$$v=\sqrt{(gR^2/r)}$$

To escape from an orbit a must tend to infinity and the escape velocity is then given by

$$v_e = \sqrt{(2gR^2/r)}$$

The orbital period for an elliptical orbit is given by

$$P = 2\pi a^{3/2}/\sqrt{gR^2}$$

Order. An integer (m) associated with a given interference fringe or diffraction pattern. In interference a bright fringe occurs for a path difference $m\lambda$; a dark fringe is produced if the path difference is $(m+\frac{1}{2})\ \lambda$. A bright fringe is first order if it arises through a path difference of one wavelength ($m=1$). Similarly, second order corresponds to $m=2$, etc.

Order-disorder Transformation

(1) The transformation in a solid solution from a state in which atoms of the various components take up preferred sites in the structure (*i.e.*, an ordered phase) to a state in which the atoms are distributed at random over these sites (*i.e.*, a phase of disorder).

(2) The reduction in the the static dielectric constant of a solid dielectric with increasing temperature, corresponding for dipolar materials to a change from a state of orientational order to one of disorder.

Order of Diffraction. A whole number which characterizes a diffraction spectrum by its displacement from the undeviated beam. In general for each order there are two spectra, one on either side of the undeviated beam.

Order of Interference. An integer which characterizes an interference fringe by the number of wavelengths in the path difference between the beams giving rise to it.

Order of Magnitude. An approximate magnitude to within a factor of 10; thus 0.01 and 0.04 are of the same order of magnitude but 10 and 1000 differ by 2 orders of magnitude.

Ordinary Ray. Birefringent crystal.

Origin

(1) Of a graphical plot referred to two or more variables : the point at which the values of the variables are zero.

(2) Of a plane projection of the Earth's surface : the point from which the coordinates of points on the projection are measured.

Orthochromatic Film. A photographic film which is sensitive to both green and blue light.

Orthogonal

(1) Mutually perpendicular, for example orthogonal lines intersect at 90°.

(2) Having or involving a set of mutually perpendicular axes, as in orthogonal crystals.

Orthographic Projection. A plane projection used for displaying the positions of the poles of a crystal. These poles are projected from the surface of the reference sphere on to the equatorial plane by dropping perpendiculars to that plane from the individual poles.

Orthohelium. Helium in which the wave function is antisymmetric, *i.e.*, changes sign when its two electrons are into changed.

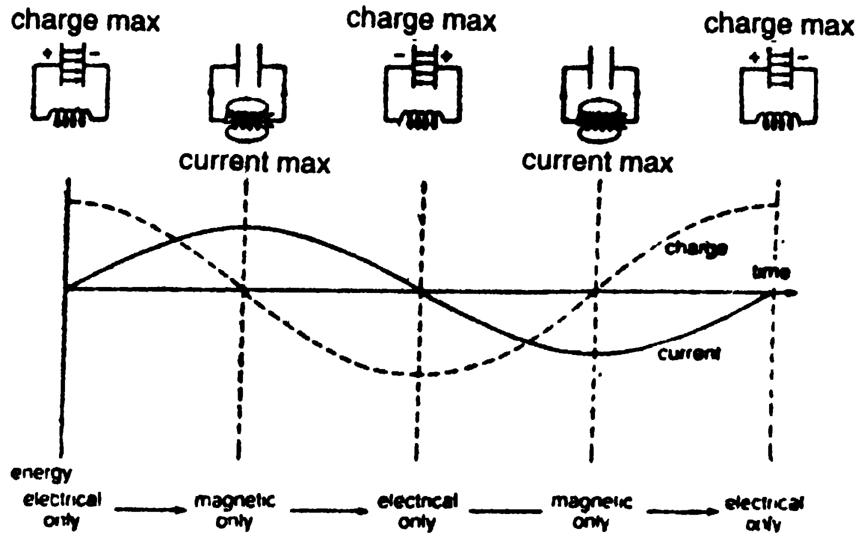
Orthotomic System. An optical system containing only rays which may be cut perpendicularly by a suitably constructed surface.

Oscillating Crystal Method. In crystal structure analysis : a modification of the rotating crystal method in which the movement of the crystal is restricted to an oscillation of a few degrees to simplify correlation between the observed reflections and the various sets of crystal planes.

Oscillation. A periodic energy variation in an electrical, mechanical or atomic system.

An electric oscillation may be demonstrated by charging a Capacitor connected in parallel with an

inductor. The charged capacitor discharges through the inductor which starts to store magnetic energy at the expense of the electric energy of the capacitor and continues to no so until the capacitor is fully discharged. The capacitor then starts to recharge but in the opposite direction until all the energy is in the electric field once more. The current then reverses and the whole process occurs in reverse order and then starts again so that continuous electric oscillation results, as indicated in fig.

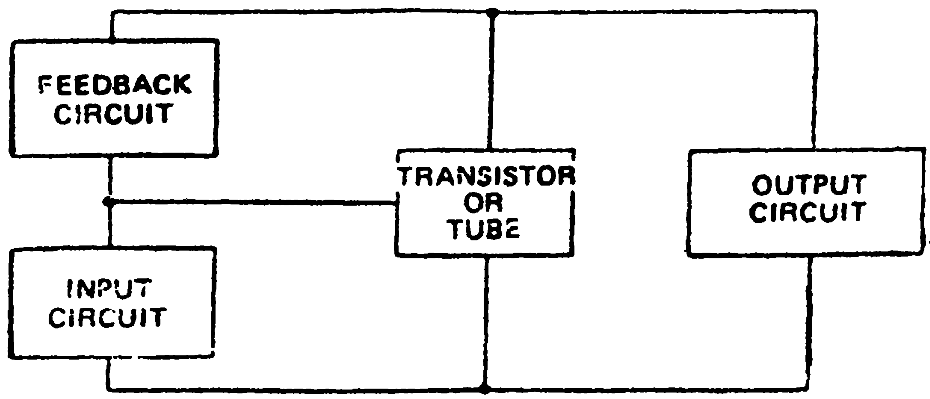


Electric oscillations and energy exchanges

Oscillator. A device that electronically produces a pulsating or alternating current. A basic oscillator can be broken down into three main sections. The frequency-determining device is usually an LC tank circuit. While the tank circuit is normally found in the input circuit of the oscillator (both transistor and electron tube), it should not be considered out of the ordinary if it appears in the output circuit of a transistor oscillator.

The differences in magnitude of collector and plate currents and shunting impedances are partly responsible for this. In both types of circuits (solid-state and tube), oscillations take place in the tuned circuit. Both the transistor and tube function primarily as an electric valve that amplifies and allows the feedback network to deliver the proper amount of energy automatically to the input circuit to sustain oscillations.

In both transistor and tube oscillators, the feedback circuit couples energy of the proper amount and phase from the output to the input circuit in order to sustain oscillations. A basic block diagram is shown in Fig. The circuit is essentially a closed loop utilizing dc power to maintain ac oscillations.



Basic oscillator circuit

Oscillogram. The image produced on the screen of an oscilloscope In some instances, this may be photographed and kept as a permanent record. The photographic print is also called an oscillogram.

Oscillograph. An instrument that makes a permanent record of a rapidly varying electrical quantity. These devices may be photographic in nature or may use inked styli to produce a hard image on graph paper. Most chart recorders fall into this category.

Oscilloscope. An instrument which displays the variation with time of the instantaneous magnitude of a physical quantity. One of the most common types is the cathode-ray oscilloscope, in which a cathode-ray tube is used.

Oseen Approximation. A modification of the Navier-Stokes equations for fluid flow past a small object, based on the assumption that the perturbation in the fluid velocity due to the presence of the object is small.

Osmometer. Any apparatus for measuring Osmotic Pressure.

Osmosis The preferential transmission by a semipermeable membrance of certain substances in solution. For example an aqueous solution of sugar in a thistle funnel sealed

by a piece of parcnment and placed in water, gains water and retains the sugar; parcnment therefore allows the passage of water molecules but not sugar molecules.

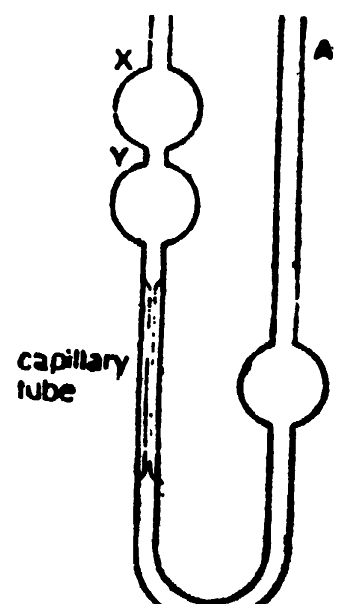
Osmotic Pressure. Symbol Π. The minimum pressure which, applied to a solution, prevents Osmosis. For dilute solutions of nonelectrolytes,

$$\Pi V = RT$$

where V is the volume of solution containing unit mass of solute, R the Universal Gas Constant and T the absolute temperature (compare Equation of State for an ideal gas). An electrolyte solution exhibits a higher osmotic pressure than the equation predicts since electrolytes onize in solution.

Ostwald Viscometer. An instrument shown in fig., for measuring the coefficient of Viscosity η_1 of a liquid by comparing its rate of flow through a capillary tube with that of a liquid of known coefficient η_2. Liquid is introduced at A, sucked up above X and the time of fall between fixed marks X and Y measured. The procedure is then repeated for an equal volume of the liquid of known viscosity coefficient. Then

$$\eta/\eta_2 = t_1\rho_1/(t_2\rho_2)$$



Ostwald viscometer

where t and p represent time and density respectively and subscripts 1 and 2 refer to the two liquids.

Otto Cycle. The thermodynamic cycle upon which the operation of spark ignition engines is based. It consists of adiabatic compression, heat addition at constant volume, adiabatic expansion, and heat rejection at constant volume.

Otto Engine. Internal-combustion engine.

Ounce

1. One sixteenth of a pound (avoirdupois), equal to 0.028349 kg.
2. Eight drachms (Troy), equal to 0.031 103 kg.
3. (Fluid ounce) Eight fluid drachms, equal to 0.028 413 dm^3.

Outer Effect. In X-ray diffraction : the effects of neighbouring atoms and molecules as opposed to those occurring inside a particular atom or molecule (the inner effect). It is of particular consequence in diffraction by liquids.

Output

1. The signal, current, voltage etc. delivered by an electric circuit or device.
2. The terminals or other place where the signal is delivered.
3. The processed data delivered by a computer.
4. The part of the computer system that converts the data into usable form. Examples are the printer, the punched card producer, magnetic tape and visual display unit.

Output Impedance. The impedance presented to the loady by a circuit or device.

Output Transformer. A transformer which couples an output circuit, usually an amplifier, to a load.

Overcurrent Release. A cut-out device which can be set to operate when the current exceeds a selected value.

Overdamping. Damping.

Overhead Projector. A type of projector able to project, on a screen, large bright images of slides or transparent objects placed on a horizontal table.

Overload. Operation of equipment in excess of normal full-load rating, or of a conductor in excess of rated ampacity, which, when it persists for a sufficient length of time. would cause damage or dangerous overheating. A fault, such as a short circuit or ground fault, is not an overload.

Overmodulation. An amplitude modulation, driving the transmitter to a level greater than 100 percent modulation. Overmodulation is an undesirable characteristic and results in extreme distortion and splatter of the received signal. Most commercially made AM transmitters designed for broadcast purposes use auxiliary equipment to limit the modulation level to 100 percent or less.

Overmodulation indicators are often used to trigger when percentage levels rise above 100 percent. These often consist of a neo bulb, magic-eye tube, light-emitting diode, or incandescent lamp, which is adapted to give an alarm when desired modulation levels are exceeded. Sometimes, an RF relay will be used in place of these other devices to trigger discrete alarm systems.

Overpotential. A potential that must be applied in an electrolytic cell in addition to the theoretical potential required to liberate a given substance at an electrode. The value depends on the electrode material and on the current density. It occurs because of the significant activation energy for electron transfer at the electrodes, and in particularly important for the liberation of such gases as hydrogen and oxygen. For example, in the electrolysis of a solution of zinc ions, hydrogen ($E^{\ominus}=0.00$ V) would be expected to be liberated at the cathode in pre-

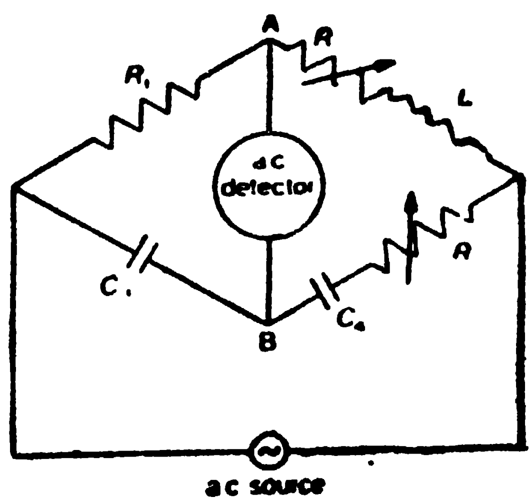
ference to zinc ($E^{\ominus}=-0.76$ V). In fact, the high overpotential of hydrogen on zinc (about IV under suitable conditions) means that zinc can be deposited instead.

Overvoltage Release. A cut-out device which can be set to operate when the voltage exceeds a selected value.

Owen's Bridge. A type of Wheatstone Bridge alternating current network, shown in fig. When there is no signal in the detector, the conditions.

$$L_2=R_1R_4C_3 \text{ and } R_1C_2=R_3C_4$$

are satisfied. To use the bridge, values for R_1, C_3 and C_4 are chosen and R_2 is varied until the detector signal is as small as possible, R_4 is then varied until the signal is a minimum. By adjusting R_2 and R_4 in turn, zero signal may be obtained and L_2 can then be calculated.



Owen's bridge

Oxygen Point. The temperature of equilibrium between liquid and gaseous oxygen at a pressure of 1.013 25×10^5 pascal. The temperature, 90.188 K, is taken as a fixed point in the International Temperature Scale.

Ozonosphere. A layer in the Earth's atmosphere containing Ozone. It extends fram 15 kilometre to 30 kilometre above the Earth's surface and absorbs the Sun's higher-energy ultraviolet radiation.

P

Pacemaker. An electronic device that is used to help control the rhythmic movements of the heart, and also to initiate cardiac beatings when the heart fails to do so its own. These devices operate by sending a stimulating current to electrodes that have been placed in contract with various heart muscles. This action triggers the beat, producing contractions at or near the normal heart rate.

Pachimeter. An instrument for measuring the elastic shear limit of a solid material.

Packing Density

1. The number of devices (such as logic circuits) or integrated circuits per unit area of a silicon chip.
2. The quantity of information stored in a specified space of a storage system associated with a computer, *e.g.* bits per inch of magnetic tape.

Packing Fraction

1. Of a nuclide: the mass decrement per nucleon expressed as a fraction.
2. Of a nucleus: the mass defect per nucleon expressed as a fraction. When expressed in terms of energy (or actual mass) the two are equivalent for a given nuclide and its nucleus except for the energies (or masses) of the atomic electrons. The packing fraction is positive for light and heavy nuclides but negative for most other nuclides.

Pair-distribution Function. For a system of particles: the probability of finding two particles at a specified distance apart.

Pair Production. The creation of an electron and a positron from a photon in a strong electric field, such as that surrounding an atomic nucleus. The electron and the positron each have a mass of about 9×10^{-31} kg, which is equivalent on the basis of the mass–energy equation ($E = mc^2$) to a total of 16×10^{-14} J. The frequency, v, associated with a photon of this energy (according to $E = hv$) is 2.5×10^{20} Hz. As a photon of this energy is in the gamma-ray range, it is only a gamma-ray photon that can cause pair production. Any energy in excess of this minimum becomes kinetic energy of the products.

Palaeomagnetism. The study of magnetism in rocks, which provides information on variations in the direction and intensity of the earth's maganetic field with time. During the formation of an igneous or sedimentary rock containing magnetic minerals the polarity of the earth's magnetic field at that time becomes 'frozen' into the rock. Studies of this fossil magnetism in samples of rocks have enabled the former positions of magnetic poles at various geological times to be located. It has also revealed that periodic reversals in the geomagnetic field have taken place (*i.e.* the N-pole becomes the S-pole and vice versa). This information has been important in the plate tectonics in establishing the movements of lithospheric plates over the earth's surface. The magnetic reversals provided crucial evidence for the sea-floor spreading hypothesis proposed in the early 1960s.

Palaeothermometer. A sensitive mass spectrometer for measuring marine temperatures in remote times by analysing the calcium carbonate from shells deposited at the relevant times. The abundance ratio of ^{18}O and ^{16}O in carbon dioxide obtained from the carbonate is determined, and since it is temperature-dependent, leads to an estimate of the temperature required. Among other things the results support the theory that the extinction of the great

dinosaurs was due to a general decline in temperature over the whole Earth.

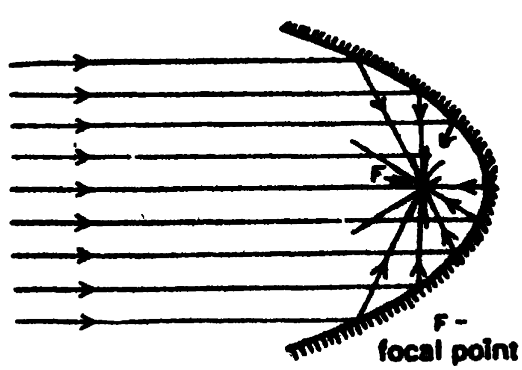
Panchromatic Film. A photographic film sensitive to all wavelengths of the visible spectrum.

Panradiometer. An instrument for recording or measuring radiant heat irrespective of wavelength, in which the radiation is absorbed by a black body, of which the temperature is measured.

Paper Capacitor. A capacitor that uses paper as its dielectric. The construction of a typical paper capacitor is shown in Fig. It consists of flat thin strips of metal foil conductors separated by the dielectric material. In this capacitor, the dielectric used is waxed paper.

Paper capacitors usually range in value from about 300 pF to about 4 μF. Normally, the voltage limit across the plates rarely exceeds 600 V. Paper capacitors are sealed with wax to prevent the harmful effects of moisture from damaging the component.

Parabolic Mirror. A reflector with a parabolic section. The converging type can converge wide parallel beams accurately into its focal point (and is thus used for reflection telescopes and solar power applications). On the other hand, radiation from a source at the focal point will be reflected into a parallel beam (as used in various lighting systems).



Parabolic mirror

Parabolic Reflector (parabolodial reflector). A reflector having a section that is a parabola. A concave parabolic reflector will reflect a parallel beam of radiation through its focus and, conversely, will produce a parallel beam if the source of the radiation is placed at its focus. Parabolic mirrors are used in reflecting optical telescopes to collect the light and in some light sources that require a parallel beam of light. In radio telescopes a dish aerial may also consist of a parabolic reflector.

Parachor. A quantity which may be regarded as the molecular volume of a liquid when its surface tension is unity. It is given by $M\sigma^{1/4}/(\varrho_l-\varrho_g)$, where M is the molecular weight, σ the surface tension, and ϱ_l and ϱ_g are the liquid and gas densities respectively.

Parallax

1. General : the apparent change in the position of an object seen against a reference background when the viewpoint is changed.
2. Of a star : the angle subtended at the star by two ends of a base-line of known length.

Parallel. Elements in an electrical circuit are in parallel if connected so that the current divides between them and rejoins at the other side. The word 'shunt' is sometimes used.

For resistors in parallel, the resulting resistance R is given by :

$$1/R=1/R_1+1/R_2+1/R_3+\ldots$$

For capacitors in parallel, the capacitance of the combination is given by :

$$C=C_1+C_2+C_3+\ldots$$

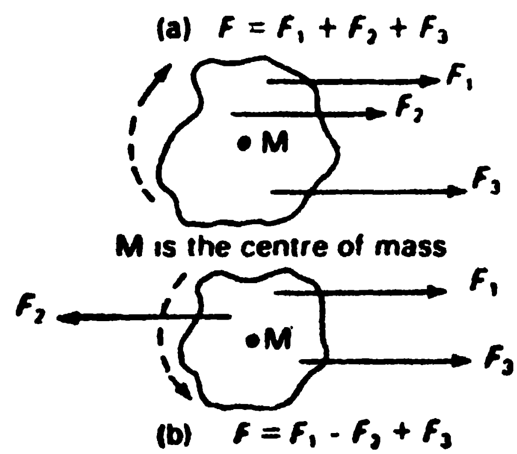
For cells in parallel, the e.m.f. is equal to the largest value of e.m.f. of all the cells. Compare series.

Parallel Axes Theorem. The Moment of Inertia of a body about any axis is equal to the sum of its moment of

intertia about a parallel axis through the centre of mass and the product of the mass of the body and the square of the separation of the axes.

Parallel Circuits. A circuit in which the circuit elements are connected so that the current divides between them. For resistors in parallel, the total resistance, R, is given by $1/R=1/r_1+1/r_2+1/r_3$......, where r_1, r_2, and r_3, are the resistances of the individual elements. For capacitors in parallel, the total capacitance, C, is given by $C=c_1+c_2+c_3$......

Parallel Forces. When the forces on an object pass through one point, their resultant can be found by using the parallelogram of vectors. If the forces are parallel the resultant is found by addition, taking sign into account. There may also be a turning effect in such cases, which can be found by the principle of moments.



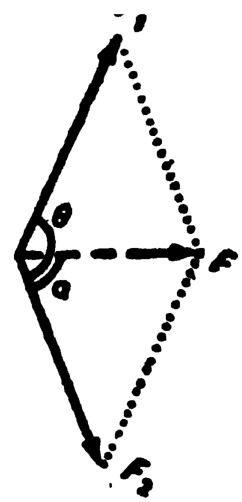
Parallel forces

Parallelogram Rule. If a Vector is completely represented in magnitude and direction by a side of a parallelogram and another vector is similarly represented by an adjacent side, then the resultant of the vectors is represented in magnitude and direction by the parallelogram diagonal drawn from the meet of the adjacent sides. Common examples of the application of the rule are to forces and velocities.

Parallelogram of Forces. Parallelogram of vectors.

Parallelogram of Vectors. A method for finding the resultant of two vectors acting at a point. The two vectors are shown as two sides of a parallelogram : the resultant is the diagonal through the starting point. The technique can be used either with careful scale drawing or with trigonometry. The trigonometrical relations give :

$$F=\sqrt{(F_1^2+F_2^2+2F_1F_2\cos\theta)}$$
$$\alpha=\sin^{-1}[(F_1/F)\sin\theta]$$



Parallelogram of vectors

Parallelogram of Velocities. Parallelogram of vectors.

Parallel Plate Capacitor. Capacitor.

Paralysis Circuit. For a counting system recording pulses : a circuit which renders the system inoperative for a predetermined time after a recorded pulse and thus allows pulses to be distinguished which would otherwise have overlapped.

Paramagnetism. The phenomenon exhibited by those substances which, under the influence of an applied magnetic field become weakly magnetized in the direction of the field but lose this directional magnetization when the field is removed. A paramagnetic substance is regarded as an assembly of Magnetic Dipoles which are normally directed at random due to thermal agitation. For small fields and high temperatures, the magnetization produced is pro-

portional to the field strength : at low temperature or high field strength, saturation is approached. The dipoles are thought to arise from electron magnetic moment due to spin and orbital motion in atoms or molecules containing unpaired electrons.

Parametric Amplifier : Reactance Amplifier. An amplifier for which the equations describing its operation contain one or more time-dependent reactance parameters. The operation of the amplifier depends on the fact that a time-varying reactance can exhibit negative resistance under some conditions and can act as a frequency converter under others.

Parapositronium. Positronium in which the positron and electron spins are anti-parallel. It decays into two photons with a mean life of about 10^{-10}s.

Parasitic Capture. The capture by an atomic nucleus of a neutron without resulting in the fission of the nucleus.

Parasitic Oscillations. Unwanted oscillations which may occur in a circuit. These oscillations are usually of much higher frequency than those for which the circuit was designed.

Paraxial. Describing rays incident on a surface close and parallel to the axis. Only paraxial rays pass or appear to pass through the focal point of a spherical reflecting or refracting surface.

Paraxial Rays. Light rays close to the Optical Axis of an optical system.

Parent. A nuclide that undergoes radioactive decay to another specified nuclide (the daughter).

Parhelion : Mock Sun. A luminous image of the Sun most frequently seen at an angular distance of about 22° from the Sun. The phenomenon is caused by refraction of the Sun's rays by ice crystals.

Parity Symbol : P. A fundamental property of a system that can be thought of as the ability to be reflected in a mirror.

If inverting all the signs of all the coordinates make no change in parity, P, then P is said to be even, and to have value +1. If the procedure inverts the sign, then parity is odd and equal to −1. Parity is a quantum number and is said to be conserved in an interaction, if the parity of the products (found by multiplying together their separate parities) is equal to the parity of the initial arrangement. Parity is conserved in strong interactions, but not in weak interactions, such as beta decay.

Parking Orbit. Another name for Stationary orbit.

Parsec. A unit of length used to express astronomical distance. The distance at which the mean radius of the earth's orbit subtends an angle of one second of arc. One parsec is equal to 3.0857×10^{16} metres or 3.2616 light years.

Partial. Any pure tone component of a complex tone, the frequency being an integral multiple of that of the Fundamental, which is not a partial (campare Harmonic). Some musicians however use partial and harmonic as synonyms.

Partial Eclipse. Eclipse.

Partial Pressure. The pressure that a gas, present in a mixture of gases occupying a fixed volume, would exert if it alone occupied the volume.

Particle

1. (In physics). One of the fundamental components of matter.
3. (In mechanics). A hypothetical body that has mass but no physical extension. As it is regarded aa having no volume, a particle is incapable of rotation and therefore can only have translational motion. Thus a real body may often, for translational purpose, be regarded as a particle located at the body's centre of mass and having a mass equal to that of the whole body.

Particle Becelerator. Accelerator.

Particle Flux Density. Of atomic or nuclear particle at a given point in space : the number of particles incident per unit time on an imaginary sphere of unit cross-sectional area centred at that point. It is identical with the product of the particle density (number per unity volume) and the average speed of the particles. Particle flux density is commonly, but incorrectly, termed particle flux.

Particle Physics. The branch of physics concerned with the properties, interactions and structure of Elementary Partir cles.

Particle Symmetry. Concerns the classification of the large number of subatomic particles discovered in recent years in terms symmetry relationships between them. The most successful way of doing this is by the use of a continuous symmetry group, known as SU(3), by which the Ω-particle was first predicted. The concept of quarks and anti-quarks also arose from the SU(3) symmetry group.

Particle Symmetry Group. A group which shows a symmetrical grouping of particles into electric charge multiplets (doublets, triplets, octuplets etc.) when the difference between the charge on a particle and the charge of the multiplet to which it belongs is plotted agaiust the hypercharge. A number of such group have been found, the most stricking being the SU(3) group, which comprises a decuplet in the form of an inverted triangle at the apex of which is the Ω-particle, a particle which was indeed predicted from the consideration of this symmetry group.

Particle Velocity. Symbol u. The alternating component of the velocity of a medium transmitting sound, *i.e.* the total velocity of the medium less the velocity not due to sound propagation.

Particle-wave Duality. A phenomenon applying to all physical entities. The choice between wave description and particle description is entirely a matter of convenience. The wave and particle aspects are linked through the relations

$$E = h\nu \quad \text{and} \quad p = h/\lambda$$

where the energy E and momentum p refer to a particle while the frequency v and wavelength λ refer to wave. The Planck Constant h appears in both equations in accordance with Relativity theory.

Partition. If a substance is in contact with different phases then, in general, it will have a different affinity for each phase. part of the substance will be absorbed or dissolved by one and part by the other, the relative amounts depending on the relative affinities. The substance is said to be partitioned between the two phases. For example, it two immiscible liquids are taken and a third compound is shaken up with them, then an equiiibrium is reached in which the concentration in one solvent differs from that in the other. The ratio of the concentrations is the partition coefficient of the system. The partition law states that this ratio is a constant for given liquids.

Partition Coefficient : Distribution Cefficient. The ratio of the equilibrium concentrations of a given substance dissolved in two specified immiscible solvents.

Partition Noise. A type of noise that is present in multigrid tubes. Partition noise is caused by some of the electrons that leaves the cathode and move through the control grid, toward the plate, reaching the plate while other strike one of the additional grids and do not arrive at the plate at all. Therefore, a random distribution of electrons between plate and other positive elements will occur and produce random variations in plate current.

Partition noise can be most troublesome. Since this type of noise is caused by grid structure, tubes containing many grids are not used in situations where noise is critical

Parton. An ultimate fundamental particles postulated as a basic unit of other fundamental particles. In the simplest theory the parton is a Quark.

Pascal. Symbol : Pa The SI unit of pressure, equal to a pressure of one newton per square metre (1 Pa=1 Nm^{-2}). The pascal is also the unit of stress.

Pascal's Law. In a confined fluid, externally applied pressure is transmitted uniformly in all directions. In a static fluid, force is transmitted at the speed of sound throughout the fluid and acts at right angles to any surface in or bounding the fluid. This principle is made use of in the hydraulic jack, the pneumatic tyre, and similar devices. The law was discovered in 1647 by Blaise Pascal (1623-62).

Paschen-back Effect. An effect similar to the Zeeman Effect but concerned with magnetic fields sufficiently strong for both the electron orbital and electron spin angular momentum vectors to each separately take up their possible orientations relative to the field direction. The resulting hyperfine structure produced in the spectral lines differs from that of the Zeeman effect.

Paschen Series. A series of lines in the infrared spectrum emitted by excited hydrogen atoms. The lines correspond to the atomic electrons falling into the third lowest energy level and emitting energy as radiation. The wavelength (λ) of the radiation in the Paschen series is given by $1/\lambda=R(1/3^2-1/n^2)$ where n is an integer and R is the Rydberg constant.

Paschen's Law. The breakdown voltage for a discharge between electrodes in gases is a function of the product of gas pressure and electrode separation.

Passive Component. An electronic component incapable of an amplifying function. Examples are resistors, capacitors and inductors.

Passive Device

1. An electronic component, such as a capacitor or resistor, that is incapable of amplification.

2. An artificial satellite that reflects an incoming signal without amplification.
3. A solar-power device that makes use of an existing structure to collect and utilize solar energy without the use of pumps, fans, etc.
4. A radar device that provides information for navigation, guidance, surveillance, etc., by receiving the microwave radiation emitted by a warm body or reflected by a body from some other source. Such a passive device emits no microwave energy itself and therefore does not disclose its position. Compare active device.

Patch Effect. The fluctuation in the response of a photocathode when a narrow pencil of light of constant intensity and composition is passed over its surface. The emission appears to be concentrated at a number of discrete patches, depending on the size and position of active crystals on that surface.

Patching. A technique used in an analog Computer to allow temporary connection of circuits.

Pauli Exclusion Principle. The principle that no two particles in a system, such as electrons in an atom, can have an identical set of quantum numbers. This principle, which was first formulated by Wolfgang Pauli (1900-58) in 1925, is now known to apply to all fermions but not to bosons.

Pauli Spin Matrices. A set of matrices introduced by Pauli in connection with electron spin in nonrelativistic Wave Mechanics.

P.D. Abbrev. for Potential Difference.

Peak Factor. The ratio of the peak value (*i.e.*, Amplitude) of an alternating quantity to its Root Mean Square value. For a sinusoidal quantity the peak factor is 2½.

Peak Limiting. The automatic limiting of the magnitude of an output signal to approximate a predetermined maximum valve. Peak limiting is accomplished electronically by

reducing amplification when the instantaneous signal magnitude exceeds the predetermined value. Peak limiting may also be called clipping because the output waveform presents a clipped appearance on the wave peaks. It may be accomplished with diodes or amplifying devices (transistors or tubes). Diode limiters or clippers may be classified according to the manner in which they are connected (series or parallel). A positive lobe circuit abolishes either part or all of that portion of a waveform that is positive in respect to some reference level. Conversely, the negative, lobe limiter affects a waveform's negative portion.

Peak Value. The maximum value attained by an alternating quantity (*e.g.*, an alternating current).

Pelleting. Another name for Sedimentation.

Peltier Effect. The change in temperature produced at a junction between two different metals when electric charge is passed through it. If the current direction is reversed then a heating effect becomes a cooling one or vice versa. The temperature change is directly proportional to the current. Compare Seebeck effect.

P-e Model of Nucleus. A model based on the assumption that nuclei are composed of protons and electrons. It failed to account for several experimental observations and was therefore abandoned.

Pencil. A narrow beam of rays from a single point.

Pencil of Light. A narrow beam of light, having a small or zero angle of convergence or divergence.

Pencil of Rays. A slender cone or cylinder of rays traversing an optical system and limited by a Stop.

Pendulum. Any rigid body that swings about a fixed point. The ideal simple pendulum consists of a bob of small mass oscillating back and forth through a small angle at the end of a string or wire of negligible mass. Such a device has a period $2\pi\sqrt{(l/g)}$, where l is the length of the

string or wire and g is the acceleration of free all. This type of pendulum moves with simple harmonic motion.

The compound pendulum consists of a rigid body swinging about a point within it. The period of such a pendulum is given by $T=2\pi\sqrt{[(h^2+k^2)/hg]}$, where k is the radius of gyration about an axis through the centre of mass and h is the distance from the pivot to the centre of mass.

Penetrameter. An assembly of pieces of matter having different opactities to X-rays, neutrons etc. (*e.g.*, a step wedge), whose main uses are in judging the quality of a radiograph and in the radiographic calibration of an X-ray or other generator.

Pentode. A thermionic valve with three grides, one grid more than the tetrode. The extra grid, called the suppressor grid, is placed between the screen grid and the anode. It is held at cathode potential, which suppresses by repulsion the loss of secondary electrons ejected by the anode. Thus the disadvantage of the tetrode is overcome.

Penumbra. The outer, partially dark, portion of the shadow of an object cas by a source of finite size, *e.g.*, the shadow of the Earth or Moon cast by the Sun, as in an eclipse. The inner, completely dark, part of the shadow is known as the umbra.

Percolation Limit. The concentration of magnetic element, in a disordered crystalline alloy having one constituent with a magnitic moment, above which the ferromagnetic state replaces the state of random orientation of atomic spins.

Perfect Fluid. A fluid whose coefficient of Viscosity is zero.

Perfect Gas. Another name for Ideal Gas.

Periastron. Of the orbit of one star about another in a binary system : the point in that orbit which is nearest to the other star.

Pericynthion. The point in the orbit around the moon of a satellite launched from the earth that is nearest to the

moon. For a satellite launched from the moon the equivalent point is the perilune. Compare apocynthion.

Perigee. The point at which a body orbiting Earth is closest to Earth.

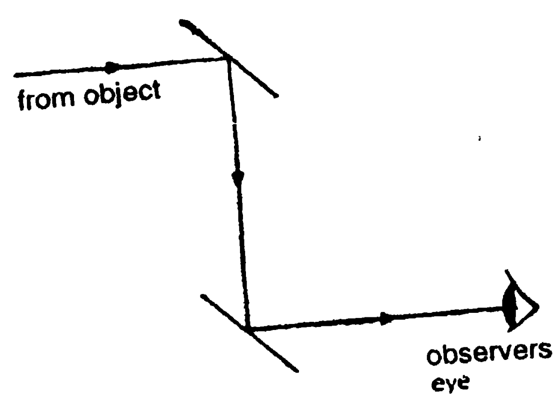
Perihelion. The point at which a body orbiting the Sun is closest to the Sun.

Period. Symbol : T the time for one complete cycle of an oscillation, wave motion, or other regularly repeated process. It is the reciprocal of the frequency, and is related to pulsatance, or angular frequency, (ω) by $T=2\pi/\omega$.

Periodic Motion. Any motion of a sytem that is continuously and identically repeated. The time T that is takes to complete one cycle of an oscillation or wave motion is called the period, which is the reciprocal of the frequency.

Peripheral Device. Any device, such as an input or output device, connected to the central processing unit of a computer. Backing stone is also usually regarded as a peripheral.

Periscope. An apparatus for viewing objects when there is no direct line of sight to the eye. In its simplest form, illlustrated in fig. the instrument comprises two parallel mirrors at 45° to the direction of view. Light from the object is turned through 90° by the top mirror, strikes the



Periscope

lower mirror and is again turned through 90° to enter the observer's eye. Total internal reflection by prisms, rather than mirror reflection, is used in better quality instruments such as submarine periscopes.

Permanent Gas. A gas which cannot be liquefied by pressure alone at normal temperatures, *i.e.* a gas requiring cooling to reach its Critical Temperature.

Permanent Magnet. A magnetized mass of ferromagnetic substance, stable against reasonable handling and of high Remanence. A definite demagnetizing field is required to remove the magnetism.

Permanent Magnet Moving-coil Meter. The basic movement used in most measuring instruments for servicing electrical equipment. The basic movement consists of a stationary permanent magnet and a moveable coil. When current flows through the coil, the resulting magnetic field reacts with the magnetic field of the permanent magnet and causes the coil to rotate. The greater the intensity of current flow through the coil the stronger the magnetic field produced; and the stronger the magnetic field, the greater the rotation of the coil.

Permanent Set. The strain remaining in a material after the removal of all stress.

Permeability

1. *Absolute permeability.* Symbol μ. The ratio of Magnetic Induction to the external Magnetic Field Strength inducing it. The unit is henry per metre.
2. *Relative permeability.* Symbol μ_r. The ratio of the absolute permeability for a given medium to the absolute permeability of a vacuum.

Permeability Curve. A plot which shows the properties of a magnetic material.

The magnetizing force (H) is plotted along the horizontal axis, while flux density (D) is plotted along the

vertical axis. The BH curves of ferromagnetic materials usually differ from each other. When the field intensity or magnetizing force is increased to a certain point, the material becomes saturated and the curve flattens out past this point. The saturation point is called the knee.

Past the saturation point, the magnetizing force has a nominal effect on the value of flux density. The permeability of the material is the ratio of B to H and is normally measured at the point where saturation is established. Fig. shows a typical permeability or BH curve.

Permitted Dosages of Radiation. Dosages laid down by the International Commission on radiological protection. For a person exposed to occupational radiation hazards, the yearly dose must not exceed 5×10^{-2} sievert of which not more than 3×10^{-2} sievert must be received in any period of 13 consecutive weeks. Anyone working in the vicinity of a radioactive area must not receive more than 1.5×10^{-2} sievert per annum. The maximum allowed dosage for the general population is 5×10^{-3} sievert per person per year.

Permittivity. Symbol ε. The ratio of the electric displacement in a medium to the intensity of the electric field producing it is important for electrical insulators used as dielectric. If two charges Q_1 and Q_2 are separated by a distance r in a vacuum, the force F between the charges is given by :

$$F = Q_1Q_2/r^2 4\pi\varepsilon_0$$

In this statement of Coulomb's law using SI units, ε_0 is called the absolute permittivity of free space, which is now known as the electric constant. It has the value 8.854×10^{-12} F m^{-1}.

If the medium between the charges is anything other than a vacuum the equation becomes :

$$F = Q_1Q_2/r^2 4\pi\varepsilon$$

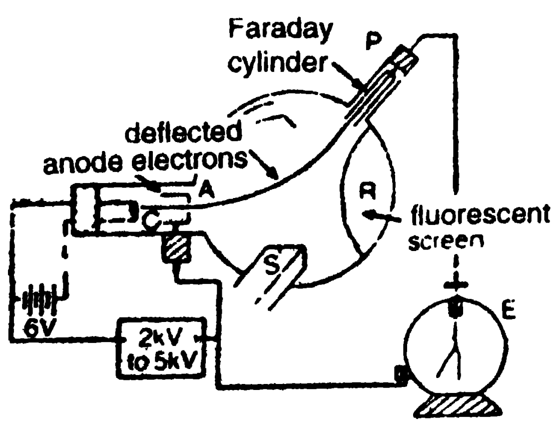
and the force between the charges is reduced. ε is absolute permittivity of the new medium. The relative permittivity

(ϵ_r) of a medium, formerly called the dielectric constant, is given by $\epsilon_r = \epsilon/\epsilon_0$.

Permittivity of Free Space. The value of the permittivity in a vacuum. In SI and MKSA units it is 8.855×10^{-12} F/m, and in CGS (e.s.u.) units it is unity (and dimensionless).

Perpetual Motion. Continuous motion without any supply of energy. It would only be possible in the absence of frictional forces. The production of useful work by a perpetual motion machine would violate the first law of Thermodynamics.

Perrine Tube. A spherical evacuated glass bulb with a side arm, illustrated in fig. A magnet placed as shown will deflect the electron beam at R from hot cathode C into the side arm P, causing the negatively charged lead of the gold leaf electroscope E to rise even further and thus demonstrating directly the negative charge on the electron.



Perrin tube

Persistence

1. The interval of time after excitation ceases during which light is emitted from the screen of a Cathode Ray Tube.
2. The faint luminosity shown by certain gases for an appreciable time after the cessation of an electric discharge in them.

Perturbation. A departure by a celestial body from the trajectory or orbit it would follow if it moved only under the influence of a single central force. According to Kepler's law, for example, a single planet orbiting the sun would move in an elliptical orbit. In fact, planets are perturbed from elliptical orbits by the gravitational forces exerted on them by other planets. Similarly, the moon's orbit round the earth is perturbed by the gravitational effect of the sun and the trajectories of comets are perturbed when they pass close to planets.

Perturbation Theory. A method of solving difficult equations that are only slightly different from ones already solved. For example the effect on the known orbit of a single planet of the presence of other planets is susceptible to this treatment. The technique is also much used in quantum mechanics.

Perversion (lateral inversion). The effect produced by a mirror in reversing images apparently left to right. Thus writing appears backwards when reflected; the image of a person raising the right hand appears to raise the left hand.

Perversion is not of unusual significance. In the case of a plane mirror it follows directly from the fact that each point of the object produces an image point that is directly opposite it behind the mirror.

Peta Symbol P. A prefix used in the metric system to denote one thousand million million times. For example, 10^{15} metres $=1$ petametre (Pm).

Phase

1. The state of vibration of a periodically varying system at a particular time. Systems vibrating with the same frequency are said to be in phase if their maximum and minimum values occur at the same time; otherwise they are said to be out of phase. In the expressions

$$y = A \sin nt, \quad y = A \sin (nt + B)$$

for two sinusoidal vibrations, B represents the phase difference between them.

2. Any of the apparent changes in the shape of the Moon in the course of its orbit round the Earth.

3. A homogeneous part of a system divided from other parts of the system by definite boundaries. Thus a mixture of ice crystals in water contains two phases but a solution of salt in water is single phase.

Phase Angle. The angle between two vectors representing two sinusoidal alternating quantities of the same frequency.

Phase-contrast Microscope. A type of microscope that is widely used for examining such specimens as biological cells and tissues. It makes visible the changes in phase that occur when nonuniformly transparent specimens are illuminated. In passing through an object the light is slowed down and becomes out of phase with the original light. With transparent specimens having some structure diffraction occurs, causing a larger phase change in light outside the central maximum of the pattern. The phasecontrast microscope provides a means of combining this light with that of the central maximum by means of an annular diaphram and a phase-contrast plate, which produces a matching phase change in the light of the central maximum only. This gives greater contrast to the final image, due to constructive interference between the two sets of light waves. This is bright contrast; in dark contrast a different phase-contrast plate is used to make the same structure appear dark, by destructive interference of the same waves.

Phase Converter. A device that will permit the operation of a three-phase induction motor from a single-phase power source. Since most commercial suppliers of power place limits on the size of single-phase motors they can serve, such limitations may also apply to three-phase motors supplied through a phase converter. The power supplier should be consulted regarding the size of converter that can be operated in a particular location.

Application of phase converters to easy-starting loads usually involves no particular problems. Such loads would include large fans and centrifugal and turbine-type irrigation pumps. For equipment that requires high starting torque or is subject to wide load fluctuation, application of a phase converter should be made only after consulting the manufacturer of the three-phase motor. Such equipment would include compressors, pumps, and barn cleaners that start under load and feed grinders and blowers on which load may vary due to uneven feeding.

Phase converters may be divided into two general types—the static converters and the rotating transformer converter. Static converter are subdivided into several types, among which are autotransformer converters, series-winding converters, and multimotor converters. Some of these must be matched in horsepower rating to the motor to be driven; that is, a 5-hp converter for a 5-hp motor, etc. The multimotor converter, as its name implies, will operate two or more motors.

The rotating transformer-type converter should have a horsepower rating as large as that of the largest motor to be driven. Additional smaller motors may be supplied by the same converter.

The starting current of a converter (three phase motor combination) is likely to be less than for a comparable single-phase motor. By the same token, the starting torque of the motor-converter combination is likely to be less than for a similar-sized single-phase motor or for a three-phase motor operated from a three-phase supply. Likewise, the motor connected through a converter may have very little short-time overload capacity.

Overcurrent protection may be difficult to provide because of the longer starting period and the unbalanced

currents that occur in the motor windings under overload conditions. Power factor is likely to be near 100 percent at rated load and slightly leading when idling off the line.

Phase Diagram. A graph showing the relationship between solid, liquid, and gaseous phases over a range of conditions (*e.g.* temperature and pressure).

Phase Difference. The difference in the phases of two coherent radiations in a superposition region. If the phase difference ($\angle\phi$) is 0, 2π, 4π, etc., the two are in phase and will interfere constructively. If $\Delta\phi$ is π, 3π, 5π, etc., the two are in anti-phase and will interfere destructively.

Phase Discriminator. A detector circuit in which phase variations in the input wave cause amplitude variations in the output wave.

Phase Modulation. A type of modulation in which a carrier wave is made to carry the information in a signal (audio or visual) by fluctuations in the phase of the carrier. The difference in phases between the modulated and the unmodulated carrier is proportional to the amplitude of the signal. The carrier remains at the same frequency. The carrier amplitude is constant.

Phase Plate. A transparent plate carrying an annular groove so that light passing through the groove differs by a quarter of a wavelength in optical path from light passing through the whole plate.

Phase Rule. For any system at equilibrium, the relationship $P+F=C+2$ holds, where P is the number of distinct phases, C the number of components, and F the number of degrees of freedom of the system.

Phase Shift. Any change occurring in the phase of one periodic quantity or in the phase difference between two or more such quantities.

Phases of the Moon. The shapes of the illuminated surface of the moon as seen from the earth. The shape changes as a result of the relative positions of the earth, sun, and moon.

New moon occurs when the nearside is totally unilluminated by the sun. As the moon moves eastwards in its orbit the sunrise terminator crosses the nearside from east to west producing a crescent moon. The moon is half illuminated at first quarter. When it is more than half-phase but less than full phase it is said to be a gibbous moon. When the moon is at opposition the nearside is fully illuminated producing a full moon. The sunset terminator then follows to produce a waning gibbous moon, last quarter, a waning crescent moon, and eventually the next new moon.

Phase Speed (phase velocity). Symbol V_p. The speed of propagation of a pure since wave. $V_p=\lambda f$, where λ is the wavelength and f is the frequency. The value of the phase speed depends on the nature of the medium through which it is travelling and may also depend on the mode of propagation. For electromagnetic waves travelling through space the phase speed c is given by $c^2=1/\epsilon_0\mu_0$, where ϵ_0 and μ_0 are the electric constant and the magnetic constant respectively.

Phase Splitter. A circuit in which a single input waveform produces two output waves of specified phase difference.

Phase Velocity. The velocity with which the phase in a travelling wave is propagated. It is equal to λ/T, where T is the period. Compare group velocity.

Phasitron. A frequency-modulator tube used to produce direct phase modulation.

Phasor. A rotating vector that represents a sinusoidally varying quantity. Its length represents the amplitude of the quantity and it is imagined to rotate with angular velocity equal to the angular frequency of the quantity, so

that the instantaneous value of the quantity is represented by its projection upon a fixed axis. The concept is convenient for representing the phase angle between two quantities; it is shown on a diagram as the angle between their phasors.

Philips Liquefier. An air liquefier based on the Stirling cycle with helium or hydrogen as the working fluid. The compression and expansion steps are carried out in a common cylinder using two pistons driven independently from a common crankshaft.

Phon Symbol : p . A unit for measuring the loudness of sounds. Noises of the same intensity sound louder or softer, depending on the frequency. The phon is defined using a standard reference source of 1000 hertz, with which other sounds are compared. A loudness of n phons is the same as that of a standard source with an intensity of n decibels above the threshold of hearing (10^{-12} W m^{-2}).

Phonic Wheel

1. A device, controlled by a tuning fork, which enables the speed of rotation of a motor to be kept constant.
2. An elementary synchronous motor driven from a valve oscillator.

Phonon. A unit of energy resulting from vibration, as in a piezoelectric crystal. When this lattice vibration occurs, a small amount of quantum energy is released.

Phonon Avalanche. In a paramagnetic crystal at a low temperature : an interaction between phonons and magnetic ions which results in the cumulative production of resonant phonons.

Phonon Bottleneck. In a paramagnetic crystal at a low temperature : an interaction between phonons and magnetic ions which results in the escape of no-equilibrium phonons being impeded.

Phosphor. A substance exhibiting Luminescence.

Phosphorescence

1. The absorption of energy by atoms followed by emission of electromagnetic radiation. Phosphorescence is a type of luminescence, and is distinguished from fluorescence by the fact that the emitted radiation continues for some time after the source of excitation has been removed. In phosphorescence the excited atoms have relatively long lifetimes before they make transitions to lower energy states. However, there is no defined time distinguishing phosphorescence from fluorescence.

2. In general usage the term is applied to the emission of 'cold light'—light produced without a high temperature The name comes from the fact that white phosphorus glows slightly is the dark as a result of a chemical reaction with oxygen. The light comes from excited atoms produced directly in the reaction—not from the heat produced. It is thus an example of chemiluminescence. There are also a number of biochemical examples (bioluminescence); for example, phosphorescence is sometimes seen in the sea from marine organisms, or on rotting wood from certain fungi (known as 'fox fire').

Phot. A unit of illumination in the c.g.s. system, equal to an illumination of one lumen per square centimetre. It is equal to 10^4 lx.

Photocathode. A cathode which emits electrons as a result of the Photoelectric Effect.

Photocell. Any device for producing an electric signal from electromagnetic radiation. Originally, photocells were photoelectric cells—*i.e.*, devices in which a current was produced between two electrodes by the photoelectric effect. The present common type depends on photoconductivity. A piece of semiconductor material is held between two contacts and a voltage applied. In the

absence of radiation the current is very small; when radiation falls on the sample, its resistance is reduced. and the current increases. Photoconductive cells, unlike photoelectric cells, can be used in the infrared region. Other types of photocell are photodiodes or depend on the photovoltaic effect.

Photochemical Reaction. A chemical reaction caused by light or ultraviolet radiation. The incident photons are absorbed by reactant molecules to give excited molecules or free radicals, which undergo further reaction.

Photochromic Substance. A substance which changes colour when light falls on it. Sometimes, when the light is cut off. the original colour returns.

Photochromism. A change of colour occuring in certain substances when exposed to light. Photochromic materials are used in sunglasses that darken in bright sunlight

Photoconduction. Electrical conduction produced in a solid by the influence of electromagnetic radiation in the range from ultraviolet to infrared, inclusive.

Photoconductive Effect. Photoelectric effect.

Photoconductivity. The increase of the electric conductivity of certain solids, usually semiconductors such as selenium, when exposed to electromagnetic radiation. It occurs when the photons have sufficient energy to raise electrons from a filled band to the conduction band.

Photodetachment. The removal by a photon of an electron from a negative ion to give a neutral atom or molecule.

Photodiode. A semiconductor Diode which is sensitive to light. When operated the diode has Reverse Bias. Minority carriers flow in the circuit and constitute a dark current. When the junction is illuminated more hole-electron pairs are produced, which are then swept across the junction, constituting the light current.

Photodisintegration. The disintegration of an atomic nucleus by a gamma ray photon or an X ray photon.

Photodissociation. The dissociation of a chemical compound into simpler molecules, or of a molecule into its component atoms, by the action of ultraviolet and visible radiation.

Photoelasticity. The study of the effects of stress in transparent materials on light traversing them. Under stress normally isotropic transparent materials may exhibit Double Refraction : marked effects are therefore produced on illuminating them with polarized light. Complex stress in structures can be investigated by stressing a model made in material showing photoelasticity, passing polarized light through the model and observing the birefringent stress patterns.

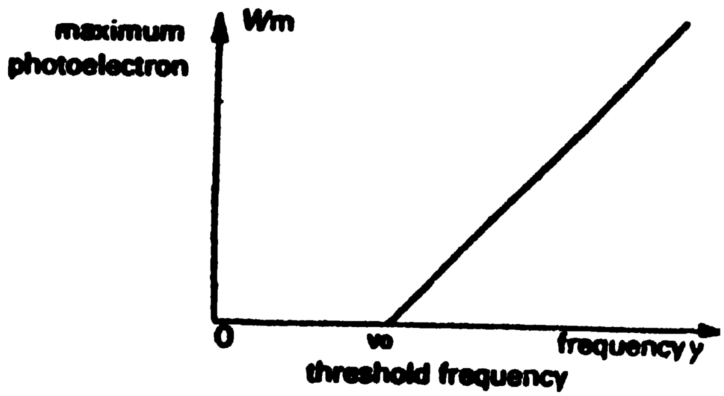
Photoelectric Cell (photocell). Any of several devices that produce an electric signal in response to exposure to electromagnetic radiation. The original photocells utilized photoemission from a photosensitive cathode (photocathode). The electrons emitted are attracted to an anode. A positive potential on the anode enables a current to flow through an external circuit, the current being proportional to the intensity of the illumination on the cathode. The electrodes are enclosed in an evacuated glass tube.

More modern light-sensitive devices utilize the photoconductive effect and the photovoltaic effect.

Photoelectric Constant. The ratio of the Planck Constant to the charge on the electron, *i.e.*, h/e.

Photoelectric Effect. The emission of electrons from a solid (or liquid) surface when it is irradiated with electromagnetic radiation. For most materials the photoelectric effect occurs with ultraviolet radiation or radiation of shorter wavelength; some materials show the effect with visible radiation.

In the photoelectric effect, the number of electrons emitted depends on the intensity of the radiation and not on its frequency. The kinetic energy of the electrons that are ejected depends on the frequency of the radiation. This was explained, by Einstein, by the idea that electromagnetic radiation consists of streams of photons. The photon energy is hv, where h is the Planck constant and v the frequency of the radiation. To remove an electron



Photoelectricity

from the solid a certain minimum energy must be supplied, known as the work function, ϕ. Thus, there is a certain minimum threshold frequency v_0 for radiation to eject electrons : $hv_0=\phi$. If the frequency is higher than this threshold the electrons are ejected. The maximum kinetic energy (W) of the electrons is given by Einstein's equation : $W=hv-\phi$. The photoelectric effect also occurs with gases.

Photoelectricity. A group of phenomena in which electric effects are produced by electromagnetic radiation.

Photoelectric Threshold. Photoelectric Effect.

Photoelectron. An electron emitted from a substance by irradiation as a result of the photoelectric effect or photoionization.

Photoelectron Spectroscopy. A technique for determining the ionization potentials of molecules. The sample is a gas or vapour irradiated with a narrow beam of ultraviolet radiation (usually from a helium source at 58.4 nm, 21.21 eV photon energy). The photoelectrons produced in

accordance with Einstein's equation are passed through a slit into a vacuum region, where they are deflected by magnetic or electrostatic fields to give an energy spectrum. The photoelectron spectrum obtained has peaks corresponding to the ionization potentials of the molecule (and hence the orbital energies). The technique also gives information on the vibrational energy levels of the ions formed. ESCA (electron spectroscopy for chemical analysis) is a similar analytical technique in which a beam of X-rays is used. In this case, the electrons ejected are from the inner shells of the atoms. Peaks in the electron spectrum for a particular element show characteristic chemical shifts, which depend on the presence of other atoms in the molecule.

Photoemission. The emission of electrons by a substance as a result of bombardment by photons, as in the Photoelectric Effect and in Photoionization.

Photofinish Camera. A camera used to record the finishing positions of contestants in a face. Commonly the film is moved behind a narrow slit in the focal plane to compensate for image movement. Sharp images of the contestants are then shown in the order in which they crossed the finishing line.

Photofission. A nuclear fission that is caused by a gamma-ray photon.

Photographic Density. A measure of the opacity of a photographic emulsion (negative or transparency).

Photographic Sensitometry. The measurement of the response, or sensitivity, to light of photographic materials. It involves a study of the treatment received by such materials (*e g*., exposure and development) and the resultant blackening.

Photoionization. The ionization of an atom or molecule as a result of irradiation by electromagnetic radiation. For a photoionization to occur the incident photon of the

radiation must have an energy in excess of the ionization potential of the species being irradiated. The ejected photoelectron will have an energy, E, given by $E=hf-I$, where h is the Planck constant, f is the frequency of the incident radiation, and I is the ionization potential of the irradiated species.

Photolithography. A technique used in the manufacture of semiconductor components, integrated circuits, etc. It depends on the principle of masking selected areas of a surface and exposing the unmasked areas to such processes as the introduction of impurities, deposition of thin films, removal of material by etching, etc. The technique has been developed for use on tiny structures (typically measured in micrometres), which can only be examined by means of an electron microscope.

Photoluminescence. Luminescence resulting from irradiation by electromagnetic radiation. Absorption of this radiation raises atoms or molecules of the luminescent substance to excited states. As the atoms or molecules return to the ground state, either directly or via an intermediate excited state, radiation of longer wavelength than the exciting radiation is emitted. Practical use is made of the phenomenon in fluorescent paints and materials. It is also used in detergent whiteners, which absorb ultraviolet radiation and then emit blue light over a long time period, thus giving white fabric a blue cast and counteracting any yellowing.

Photolysis. The chemical decomposition or dissociation of molecules due to the absorption of electromagnetic radiation.

Photometer An instrument for determining illumination or luminous intensity by comparisons made with the eye. There are various types. The general principle is to compare a source with a standard source. The two sources each illuminate a screen, and the positions of the sources are adjusted until both give equal illumination.

The illumination (E) is related to luminous intensity by $E = (I \cos i)/d^2$, where I is the luminous intensity, d the distance from the source to surface, and i the angle of incidence.

Photometer Head. That portion of a visual photometer in which photometric comparison is effected, or that part of a physical photometer which contains the light-sensitive element.

Photometry The study of visual radiation, especially the calculations and measurements of luminous intensity, luminous flux, etc. In some cases photometric calculations and measurements extend into the near infrared and the near ultraviolet.

In photometry, two types of measurement are used : those that measure luminous quantities rely on the use of the human eye (for example, to compare the illuminance of two surfaces); those called radiant quantities rely on the use of photoelectric devices to measure electromagnetic energy.

Photomicrography. The production of macroscopic images of microscopic objects, by an optical system of which a microscope forms a part. It should not be (but often is) confused with microphotography.

Photomultiplier. A device in which electrons originally emitted from a photocathode initiate a cascade of electrons by secondary emission in an electron multiplier. It is much more sensitive as a radiation detector than a single photoelectric cell.

Photon. A particle with zero rest mass consisting of a quantum of electromagnetic radiation. The photon may also be regarded as a unit of energy equal to hf, which h is the Planck constant and f is the frequency of the radiation in hertz Photons travel at the speed of light. They are required to explain the photoelectric effect and other phenomena that require light to have particle character.

Photoneutron. A neutron emitted by an atomic nucleus undergoing a photonuclear reaction.

Photonuclear Reaction. Another name for Photodisintegration.

Photopic Vision. Vision at normal levels of light intensity (as in normal daylight). Under such conditions the cones in the retina are the main receptors. Compare scotopic vision.

Photoreactivation : Ehrenhaft effect. **Photorestoration.** The recovery of a biological material from the effects of ultraviolet radiation, which is effected by further irradiatic to light of somewhat longer wavelength (*i.e.* longer wavelength ultraviolet or short wavelength visible light).

Photoreceptor. A sensory cell or group of cells that reacts to the presence of light. It usually contains a pigment that undergoes a chemical change when light is absorbed, thus stimulating a nerve.

Photoresistor. A semiconductor resistor that changes its internal resistance in direct proportion to the amount of ambient light present. They may also be called photocells, solar resistors, or cadmium-sulfide cells, depending on the structure of the semiconductor material.

The photoresistor is a passive device and does not convert light into electrical energy. Photoresistors operate as they do because of the photoelectric effect, which is the phenomenon whereby temporary changes occur in the atoms of certain substances under the influence of light. Some of these materials undergo a change in electrical resistance, which is lowered as light levels increase.

Photoresistors are often used in photographic light meters and as triggers for electronic relays that are activated by ambient light levels. These are normally small devices that will exhibit a maximum resistance of several megohms when in complete darkness. * When

subjected to intense light, their internal resistance will drop, often to below 100 Ω.

Photosculpture. The use of enlarged photographs of a subject, taken at various angles, as a guide to the sculpturing of the subject.

Photosensitive Substance

1. Any substance that when exposed to electromagnetic radiation produces a photoconductive, photoelectric, or photovoltaic effect.
2. Any substance, such as the emulsion of a photographic film, in which electromagnetic radiation produces a chemical change.

Photosphere. The visible surface of the sun or other star and the source of its absorption spectrum. It is a gaseous layer several hundreds of kilometres thick with an average temperature of 5780 K. Where the photosphere merges with the chromosphere the temperature is 4000 K.

Phototemplate. An exact full-scale pattern, obtained photographically, used as a guide in cutting out or machining some part of a manufactured article or mechanical structure. The process used involves the projection of a photographic negative on to a sensitized metal sheet, development of which produces an outline of the pattern on the metal.

Phototransistor. A bipolar junction Transistor with floating base electrode. The base signal is supplied by excess carriers produced by illumination of the base. The emitter current depends on the illumination until equilibrium is established between base recombination and carrier generation, when the emitter current saturates.

Phototrophic Substance. Another name for Photochromic Substance.

Phototube. A device that responds to light and is the basis of many electronic controls. This tube is essentially a diode;

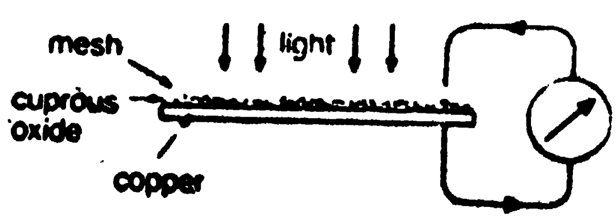
and like all diodes, it has two electrodes, an anode, and a cathode. Current will flow when the anode is positive with respect to the cathode, provided that the cathode is illuminated.

In rectifier tubes, the cathode releases electrons when heated. In the phototube, the cathode will release electrons when light strikes it. Thus, there are two requirements for the phototube action : The anode must be positive, and the cathode must have light falling on it. The more light that falls on the phototube cathode, the greater the current flow through the tube. At best, however, this current will be very small, about 20 millionths of an ampere. It is so small that it cannot do much work and must be used in conjunction with an amplifying triode to close a relay, which, in turn, can start or stop a motor.

Photovoltaic Cell. Also known as a photochemical cell :

1. An electrolytic cell which sets up an electromotive force when exposed to radiation, commonly light.
2. A cell which generates a potential in the barrier layer of an electrode consisting of two types of material, when radiation is incident upon it. Such cells are in common use as radiation detectors. They are also known as barrier-layer photocells and rectifier photocells.

Photovoltaic Effect. The production of an electromotive force between two layers of different materials when electromagnetic radiation is incident on the surface layer. An example is the cuprous oxide/copper cell illustrated in fig.



Photovoltaic cell

The wire mesh enables electrical contact to be easily made to the oxide surface. It is assumed than an extremely thin barrier exists between the oxide and the copper. As a result. electrons liberated in the oxide by the radiation can readily pass to the copper but are blocked from returning. The electromotive force tending to return the electrons produces the current in the external circuit. Other combinations, such as the Selenium Cell, also show the effect.

Physical Colour. The colour sensation produced by a stimulus in relation to the spectral distribution of the stimulus.

Physical Optics. Optics.

Physics. The study of matter and energy without reference to chemical changes occurring. Traditional physics covers heat, light, sound, electricity and magnetism. Modern physics extends the study to atomic, nuclear and particle physics, relativity and quantum mechanics.

Physics. The study of the laws that determine the structure of the universe with reference to the matter and energy of which it consists. It is concerned not with chemical changes that occur but with the forces that exist between objects and the interrelationship between matter and energy. Traditionally, the study was divided into separate fields; heat, light, sound, electricity and magnetism, and mechanics. Since the turn of the century, however, quantum mechanics and relativistic physics have become increasingly important; the growth of modern physics has been accompanied by the studies of atomic phsics, nuclear physics, and particle physics. The physics of astronomical bodies and their interactions is known as astrophysics, the physics of the earth is known as geophysics, and the study of the physical aspects of biology is called biophysics.

Physiological Colour. The colour sensation produced by a stimulus in relation to the response of the eye to the stimulus.

Physiological Effects of Acceleration. The effects of acceleration on the human body. The subject has greatly increased in importance since the start of the space age. One rocket takeoff an astronaut can experience an acceleration six times that due to gravity, making lying on a specially designed couch essential during the acceleration period. Even so, arms and legs feel leaden and are difficult to raise, internal organs are compressed, breathing requires much effort and loose facial skin is drawn tight against the skull. When in orbit the acceleration vanishes: long-term effects of this are under study.

Physiological Optics. The analytical assessment of the reception of light by the eye and the processing of the resulting signals by the nervous system.

Pi Symbol π. The ratio of the circumference of a circle to its diameter, equal to 3.141 592 653...

Pick-up. A Transducer which converts recorded information into electric signals. Thus the mechanical vibration produced in a pick-up by its contact with the grooves in a record will stress a Piezoelectric Crystal or ceramic device and so cause an electromotive force in it. In a magnetic pick-up the vibration causes movement in a small induction coil, thus changing the magnetic flux through it and hence the current in it. Each kind of pick-up thus provides an electrical signal for the audio system.

Pico- Symbol. p A prefix denoting 10^{-12}. For example, 1 picofarad (pF)$=10^{-12}$ farad (F).

Pictet Method. A method of gas liquefaction using compression and expansion.

Pie Chart. A diagram in which percentages are shown as sectors of a circle. If x per cent of the electorate vote for party X, y per cent for party Y, and z per cent for party Z, a pie chart would show three sectors having central angles 3.6x°, 3.6y°, and 3.6z°.

Pi Electron. An electron in a pi orbital.

Piezoelectric Crystal. A crystal showing the Piezolectric Effect.

Piezoelectric Effect. The production of electric charges of opposite sign at opposite ends of certain crystals when such crystals are compressed or extended in particular directions. Conversely, the production of a strain in certain directions when an electric field is applied. Substances which have a centre of symmetry do not show the piezoelectric effect but all crystals show a second-order effect, electrostriction or the electrostrictive effect, in which a strain appears when an electric field is applied.

Piezoelectric Oscillator. An oscillator formed from a suitably cut piezoelectric crystal which is mounted between two electrodes. The oscillator is most conveniently set into vibration by connecting it to a source of undamped electric oscillations. The can be done in various ways, for example the oscillator circuit tuned to very near the crystal frequency can be coupled to the crystal, which will then maintain the oscillator frequency without drift at the crystal frequency.

Pilot Balloon. A small balloon, tracked by a theodolite, used to determine the strength and direction of the wind.

Pi Meson : Pion. The meson that is principally concerned in nucleon-nucleon forces.

Pinch Effect. A magnetic attraction between parallel conducors carrying currents flowing in the same direction. The force was noticed in early induction furnaces. Since the late 1940s it has been widely studied as a means of confining the hot plasma in a thermonuclear reactor. In an experimental toroidal thermonuclear reactor a large electric current is induced in the plasma by electromagnetic induction; this current both heats the plasma and draws it away from the walls of the tube as a result of the pinch effect.

P-i-n Diode. A semiconductor Diode with a region of almost Intrinsic Semiconductor between the n-type and p-type regions.

Pin-hole Camera. A box into which light can enter only through a very small hole. Because light rays travel in straight lines in a given medium (air in this case), an inverted image is formed on the well of the box opposite the pin hole. The wall may carry a photographic plate, or be made of a diffusing material such as tissue paper or ground glass.

Because the hole is small, the image is very faint—a long exposure is needed to make a photograph. However the image is in sharp focus, whatever the distance of the object. This is because the rays pass through the hole without deviation. Unlike the lens of a lens camera, the pin hole gives no image aberrations. If the hole is made larger, the image becomes brighter—but more blurred. A large hole can be thought of as a set of pin-holes—each pin hole gives a faint image, but the images are in slightly different positions.

Pink Noise. Interfering noise that occurs over a small specific frequency range. This often occurs in radio receivers that are operated near a defective ac power line. The noise is frequency selective and will be tuned at one frequency and not at any others.

Pion (pi-meson). A type of meson. There are three types of pion, having positive, negative, or zero charge. The charged pions are antiparticles of each other.

Pipe Diffusion. Atomic migration along dislocation lines in metals.

Pirani Gauge. A gauge for measuring low gas pressures in the range 1 pascal to 10^{-3} pascal. It consists of an electrically heated, wire mounted in the gas. The conduction of heat from the wire by the gas, and hence the temperature and resistance of the wire, depend on the gas pressure.

Therefore by measuring the potential difference necessary to keep the wire resistance constant at different gas pressures, the pressures can be found.

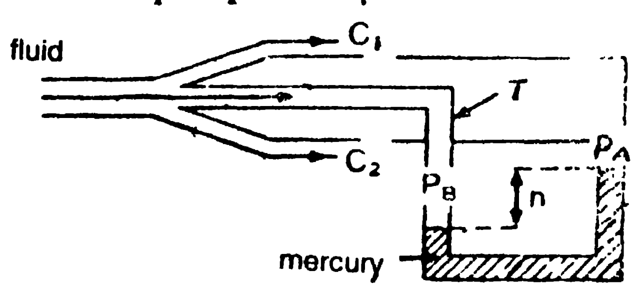
Piston Attenuator. In a waveguide : a variable length of cut-off waveguide in which one of the coupling devices is carried on a sliding member like a piston.

Pitch. The sensation that a sound produces in a listener as a result of its frequency (though other factors are involved). High-pitched notes are high-frequency vibrations and low-pitched notes are low-frequency vibrations.

Pitching. Of a ship at sea or an aircraft in the air : the movement of the ship or aircraft about the lateral axis.

Pitot Tube. A measuring device for flow velocity. It is inserted into a horizontally flowing fluid as shown in fig. The fluid entering the narrow inner tube T will come to rest at some point B. Then by the Bernoulli Equation,

$$p_B = p_A + 0.5\,\rho v^2$$



Pitot tube

where p_A and p_B are the pressures at A and B respectively; ρ and v are respectively the fluid density and flow velocity. The pressure at C_1 and C_2 is p_A, hence the pressures on the mercury are as shown. Thus if h is the difference in mercury levels,

$$p_B - p_A = g\rho' h$$

where ρ' is the mercury density and g the acceleration due to gravity. Equating the two expressions for $p_B - p_A$ gives

$$g\rho' h = 0.5\,\rho v^2$$

i.e.,

$$v = (2g\rho' h/\rho)^{1/2}$$

The flow velocity may therefore be calculated. The tube should be carefully constructed to avoid eddies,' which would produce serious errors. Such tubes have been used to study the velocity of arterial blood flow. They have many industrial applications. Compare Venturi Meter.

Planar Transistor. A transistor in which the emitter, base, and collector elements terminate on the same face (plane) of the silicon wafer. A thin film of silicon dioxide is grown on top of the wafer to insulate the exposed junctions after the leads have been attached; *i.e*, the transistor is passivated.

Planck. The unit of Action, equal to 1 joule second.

Planck Constant. Symbol h. The fundamental constant equal to the ratio of the energy of a quantum of energy to its frequency. It has the value $6.626\,196 \times 10^{-34}$ J s. It is named after **Max Plank (1858—1947).**

Plank Function. Symbol Y. The function—G/T where G is the Gibbs Free Energy and T the thermodynamic temperature.

Planck's Formula. Planck's radiation law.

Plank's Law. The energy of electromagnetic radiation occurs in small individual packets of photons, each of energy hv where h is the Planck Constant and v the frequency of the radiation. This law is the basis of Quantum Theory.

Planck's Radiation Law. A law giving the distribution of energy radiated by a black body. It introduced into physics the novel concept of energy as a quantity that is radiated by a body in small discrete packets rather than as a continuous emission. These small packets became known as quanta and the law formed the basis of quantum theory. The Plank formula giving the energy M radiated in unit time by unit area of a surface at thermodynamic temperature T for wavelength λ is given by :

$$M = C_1\lambda^{-5}/(\exp C_2\lambda T - 1),$$

where $C_1=2\pi hc^2$ and $C_2=hc/k$. In the constants C_1 and C_2, h is the Planck constant, c is the speed of light, and k is the Boltzmann constant.

Plane Mirror. A polished flat metal surface or similar device.

Plane of Flotation The plane in which the liquid surface intersects a stationary body floating in the liquid.

Plane of Polarization. For historical reasons, this is defined as the plane containing incident and reflected rays in cases of polarization by reflection. It is therefore the plane containing the magnetic vector B, rather than the electric vector E.

Plane of Symmetry. A plane such that the two parts into which it may be considered to divide a system are mirror images of each other in that plane.

Plane Polarization. A type of polarization of electromagnetic radiation in which the vibrations take place entirely in one plane. It can be produced by reflection, or by transmission through a Nicol prism or through Polaroid.

Plane Progressive Wave. A wave described by the equation

$$y=a \sin 2\pi(t/T-x/\lambda)$$

where at time t the displacement is y at a distance x from the origin; a, T and λ are respectively the amplitude, period and wavelength of the wave. For a given value of x, the equation gives the time variation at that x value; for a given value of t, the equation gives the wave form at that instant.

Plane-polarized Light. Polarization of light.

Planet. A massive body revolving around a star and visible only by the light it reflects from the star : it is not self-luminous. From Earth, eight other planets are visible.

Planetarium. A building in which spectators can see a realistic reproduction of the whole night sky. A complex optical projection instrument, situated at the centre of a hemispherical dome, projects images of the Sun, Moon, planets,

and stars on the inner surface of the dome, and the motions of the various celestial objects are presented by appropriate movements of one or more of the projectors of which the instrument is composed.

Planetary Electron. An electron orbiting around the nucleus of an atom.

Planetary Radar. That branch of radar astronomy which is concerned with such information as the positions, velocities, and physical states of planets.

Planetoid. Another name for Asteroid.

Planimeter. An instrument used to measure the area of a closed curve. The outline of the curve is followed by a pointer on the instrument and the area is given on a graduated disc.

Plano-concave Lens. A diverging lens with one plane face and one concave face.

Plasma. A mixture of free electrons and ions or atomic nuclei. Plasmas occur in thermonuclear reactions, as in the Sun. The glowing region of ions and electrons in a discharge tube is also a plasma. Sometimes plasmas are referred to as a fourth state of matter.

Plasma Frequency. The natural frequency of oscillation of a plasma, arising from the collective motion of the electrons. It is proportional to the square root of the electron density.

Plasma Torch. A device used to heat gases electrically to very high temperatures. The hot gases can be used for such purposes as chemical synthesis and metal fabrication.

Plastic Deformation. A phenomenon which occurs when a material is stretched beyond its Elastic Limit. It is caused by movement of crystal planes, which occurs at the site of a lattice Defect.

Plastic Flow. A phenomenon which occurs in materials stretched beyond the Yield Point. The end point of plastic flow is when breaking occurs.

Plasticity. The property of solids that causes them to change permanently in size or shape as a result of the application of a stress in excess of a certain value, called the yield point.

Plastometer. An instrument for determining plasticity, typically from the measurement of the rate of approach, for a given load, of two plates between which the substance under investigation is placed.

Plate. Another name for the anode of an electron tube. This term may also describe one of the electrodes of a primary or secondary battery cell or one of the electrodes of a capacitor Often, plate identifies the positive electrode of a number of different electronic components or devices.

Plate Current. The direct current that flows in the plate circuit of an electron tube. Abbreviated I_p, when this value is multiplied by the plate voltage potential, the product is equivalent to the total plate power input. Plate current, along with plate voltage, must be monitored in many types of radio-frequency amplifiers according to Federal Communications Commission regulatians. These are usually the sole determining factors of total power input, which must be kept to a specific level in many commercial, business, and amateur radio applications.

Plate Resistance. Abbreviated r_p, the total resistance of the internal plate circuit of an electron tube. Alternately, it may be the resistance of the internal plate and all external circuitry attached to this electrode. Plate resistance is measured in ohms. The static value of plate resistance is equal to the resting plate voltage divided by the resting plate current. The dynamic resistance value is equal to maximum plate voltage divided by maximum plate current. Plate resistance may also be a resistor connected

in series with the tube plate and the plate power supply, although this component is more often referred to as a plate resistor

Plate Tectonics. A theory which postulates that the Earth's crust contains rigid regions known as plates which have moved throughout time to give the current continent positions. Six major plates and a number of smaller ones have been proposed. Seismic and volcanic activity is thought to occur at the plates' margins, where also material disappears or is produced. Terrestrial Magnetism observations lend support to the theory.

Platinum Resistance Thermometer. A type of Resistance Thermometer.

Plate Voltage. The dc potential applied to the plate electrode of an electron tube. It is abbreviated E_p and is normally the highest voltage required of any element within the tube proper. Plate voltage potential can range from less than 25 V in some low-power applications to 15,000 V or more in extremely high-powered radio and television transmitters.

Plate voltage power supplies nearly always produce a dc output, although some specialized electronic circuits may dictate an ac potential. In amplifier circuits, the stability of the voltage value of the plate supply is important, especially when high to moderate current is being drawn. In frequency-determining circuits, a change in the plate voltage supply can bring about a subsequent change in frequency. The term plate voltage applies only to electronic circuits that use vacuum tubes. This voltage may also be referred to as B+, which is a throwback to the older days of electronics when storage batteries were often used for portable equipment.

In many applications, plate voltages values are high enough to be deadly. Radio-frequency amplifiers with output powers of 500 W or more typically require plate supplies in excess of 1000 V. The equivalent of plate

voltage in transistorized circuits is called collector voltage and is normally at a potential of less than 100 V and typically 25 V or less. Using solid-state circuitry, the same voltage hazards are not often encountered as in circuits that use vacuum tubes.

Pleochroic. Denoting a crystal that appears to be of different colours, depending on the direction from which it is viewed. It is caused by polarization of light as it passes through an anisotropic medium.

Pleochroic Halo. A small coloured ring or group of concentric rings found in certain minerals (*e.g.* mica) which contain radioactive inclusions. The colour is due to damage caused by α-particles, which produce maximum ionization at the end of their range, which is 10-50 μm in most minerals.

Plethysmography. The measurement of volume changes at the extremity of a part of the body caused by changes in the rate of blood low.

Plugging. The process of braking in an electric motor in which connections are reversed. This reversal causes the motor to develop a counter torque, which results in the exertion of a retarding force. Plugging is used to secure both rapid stop and quick reversal.

Because it is possible for motor connections to be reversed when the motor is running, control circuits should be designed specifically to prevent this from occurring when it is undesirable. However, there are a number of factors that must be considered and investigated thoroughly when it is desired to have this type of operation. It may be necessary to have methods of limiting maximum permissible currents, particularly in situations with repeated operations and also with dc motors. The machine under consideration should be carefully investigated in order to ensure that this type of action wiil not do damage over an extended period of time.

Plum Pudding Atomic Model. A model in which the nucleus was considered to occupy most of the atom and electrons to be scattered throughout it like currants in a plum pudding. The concept was shattered by Geiger and Marsden's Experiment.

Pluto. The outermost planet in the solar system. Its diameter is about a fifth of Earth's its period of orbital rotation and of axial rotation respectively about 248 year and 6 day. The temperature is around 63 K.

Pneumatic Gauging. A technique by which a dimensional change is converted into a change in flow rate in a pneumatic circuit. Typically the measurement involves the position of a barrier situated in front of an air outlet, the displacement of the barrier changing the flow through the outlet, which may be accurately measured.

Pneumatics. The branch of physics dealing with the dynamic properties of gases.

P-n Junction. The region where a P-type and an N-type Semiconductor meet. The behaviour of such a junction depends on the geometry, bias conditions and doping level in each semiconductor region. Usually opposite types of the same material are used to produce a simple p-n junction, but dissimilar materials are sometimes used, the junction then being known as a hetero-junction. If Reverse Bias is applied to the p-type component, a depletion layer is produced at the junction and very little current flows until breakdown occurs. Under bias in the opposite direction. *i.e*, forward bias conditions, a current flows in the external circuit since carriers are attracted across the junction into the region of opposite type.

P-n Model of the Nucleus. The model based on the assumption that nuclei are composed of neutrons and protons.

PNP Transistor. A bipolar junction transistor that utilizes a PNP junction. Two sections of P-type semiconductor material are sandwiched around a section of N-type material. The P-type semiconductor slabs form the col-

lector and emitter connections, while the N-type material is the base. PNP transistors of similar types may be substituted for NPN transistors in most circuits as long as circuit polarity is reversed.

Pockels Effect. The alteration in the refractive properties in a piezoelectric crystal by the application of a strong electric field. The effect is used in the Mekometer to produce a light beam modulated at microwave frequency.

Poggendorf Compensation Method. A method of determining an e.m.f. by balancing it against the voltage drop along a uniform resistance wire in a potentiometer.

Poikilothermic. Having or concerning a temperature which varies with the surroundings. It describes, for example, a cold-blooded animal.

Point Contact Transistor. An early form of transistor. now; obsolete.

Point Deffect. A crystal defect which is located at a point in the crystal structure. It may arise from a missing atom which leaves behind a vacant lattice site; or it may be an intruder atom which takes up a position between the normal atomic positions, and is known as an interstitial atom; or it may be an impurity atom, which may occur as an interstitial atom or may be substituted for a normal atom. A vacancy-interstitial pair, produced when an atom is displaced (leaving a vacancy) to take up an interstitial position, is known as a Frenkel defect. A Schottky defect is formed either as a vacancy when an atom is displaced and moves to the surface, or as an interstitial when an atom moves in from the surface. In this context "suface" is meant to include grain boundaries or dislocations.

Point Discharge. Corona.

Point-group. One of the thirty-two groups of macroscopic symmetry elements which correspond to the thirty-two crystal classes.

Point Source. A source of exactly spherical wave fronts. All sources can be considered to be point-like if viewed from a large enough distance. The stars provide an obvious example.

In a number of practical situations, sources that are effectively point sources are required. Normally a small hole in an otherwise opaque illuminated surface is used. Holes can be made as small as 100 μm; the main problem is to arrange adequate illumination of the hole by the real source.

Points. Action at. A phenomenon which arises because the surface density of charge at a point on a conductor is much greater than for a smooth part of the conductor. The associated high electric field strength at the point is conducive to starting an electric discharge from the point, *i e.*, to promoting action at it.

Poise. A c.g.s. unit of viscosity equal to the tangential force in dynes per square centimetre required to maintain a difference in velocity of one centimetre per second between two parallel planes of a fluid separated by one centimetre. 1 poise is equal to 10^{-1} N s m^{-2}.

Poiseuille's Equation. An equation relating the volume flow rate, V, of a fluid through a cylindrical tube to the pressure difference, p, between the ends of the tube : $V = \pi pr^4/8l\eta$, where r is the radius and l the length of the tube; η is the viscosity of the fluid. It applies if the Reynolds number is less than 2000 and was first stated by Jean Louis Poiseuille (1799 – 1869).

Poison. A substance that absorbs neutrons in a nuclear reactor and therefore slows down the reaction. It may be added intentionally for this purpose or may be formed as a fission product and need to be periodically removed.

Poisson's Ratio. The ratio of the lateral strain to the longitudinal strain in a stretched rod. If the original diameter of the rod is d and the contraction of the diameter under

stress is Δd, the lateral strain $\Delta u/=s_d$; if the original length is l and the extension under stress Δl, the longitudinal strain is $\Delta l/l=s_l$. Poisson's ratio is then s_d/s_l. For steels the value is between 0.28 and 0.30 and for aluminium alloys it is about 0.33. It was first introduced by Simeon Poisson (1781 – 1840).

Polarimeter (saccharimeter). A device for measuring the angle of rotation of a plane-polarized beam caused by an optically active sample. Typically, light from a source is passed through a Nicol prism (the polarizer) to plane-polarize it, then through the sample. The amount of rotation is measured by a second prism (the analyser), which can be turned on an angular scale. The position of minimum transmission is observed. As this angle depends, among other things, on the concentration of an active solute, polarimeters are used to measure this.

Polarimetery. The measurement of optical rotation.

Polariscope. (polarimeter). A device used to study optically active substances (optical activity). The simplest type of instrument consists of a light source, collimator, polarizer, and analyser. The specimen is placed between polarizer and analyser, so that any rotation of the plane of polarization of the light can be assessed by turning the analyser.

Polarization

1 The process of confining the vibrations of the vector constituting a transverse wave to one direction. In unpolarized radiation the vector oscillates in all directions perpendicular to the direction of propagation.

2. The formation of products of the chemical reaction in a voltaic cell in the vicinity of the electrodes resulting in increased resistance to current flow and, frequently, to a reduction in the e.m.f. of the cell.

3. The partial separation of electric charges in an insulator subjected to an electric field.

Polarization, Angle of. Brewster angle.

Polarization, Electrolytic. The reduction of current in a voltaic cell, caused by the build-up of products of the chemical reaction. Commonly, the cause is the build-up of a layer of bubbles (*e.g.*, of hydrogen). This reduces the effective area of the electrode, causing an increase in the cell's internal resistance. It can also produce a back e.m.f. Often a substance such as manganese dioxide (a depolarizer) is anded to prevent hydrogen build-up.

Polarization, Electric. The separation of the charges in the molecules of an insulator as an effect of an electric field. One face of an insulator in a field gains a net positive charge with the other becoming negative.

Polarization of Light. The process of confining the vibrations of the electric vector of light waves to one direction. In unpolarized light the electric field vibrates in all directions perpendicular to the direction of propagation. After reflection or transmission through certain substances (Polaroid) the electric field is confined to one direction and the radiation is said to be plane-po-larized light. The plane of plane-polarized light can be rotated when it passes through certain substances.

In circularly polarized light, the tip of the electric vector describes a circular helix about the direction of propagation with a frequency equal to the frequency of the light. The magnitude of the vector remains constant. In elliptically polarized light, the vector also rotates about the direction of propagation but the amplitude changes; a projection of the vector on a plane at right angles to the direction of propagation describes an ellipse. Circularly and elliptically polarized light are produced using a retardation plate.

Polarizer. A device which produces planepolarized light from a beam of unpolarized light passing throught it. It may be a polarizing prism or a polaroid sheet.

Polarizing Angle. Of a beam of electromagnetic waves : the angle at which a beam of such waves, reflected by a refracting medium, is completely plane polarized.

Polar Molecule. A molecule that has a dipole moment; *i.e.*, one in which there is some separation of charge | in | the | chemical bonds, so that one part of the molecule has a positive charge and the other a negative charge.

Polariod. A type of transparent film containing many very small doubly refracting crystals aligned with their axes parallel. Incident light is doubly refracted, one plane polarized component being absorbed and the other transmitted. Stray polarized light arising, for example, by reflections is reduced by the film, which is therefore used in sun glasses to reduce glare.

Polaroid Camera. A camera which yields finished positive prints or transparencies about 10 seconds after exposure for monochrome, and about 60 second after exposure for colour.

Pole (optical centre, optic centre). The geometric centre of a surface or a lens. In ray diagrams rays can be drawn undeviated through the pole of a lens. At the pole of a mirror the incident and reflected rays make equal angles with the principal axis. All distances from a refracting surface, reflector, or lens—object and image distances, focal distances, radii of curvature, etc.—are measured from the pole.

Pole Figure. A steregraphic projection showing the contours of pole density for a specified set of crystal planes. Pole figures are used to convey an accurate description of preferred orientation in polycrystalline materials.

Poles, Magnetic. The regions of a magnetic field where the forces appear strongest. Thus, in a bar magnet, the lines of force appear to diverge from and converge to two small regions near the ends, these being the poles of the magnet. The concept of magnetic 'pole', however, has

no more reality than that of 'regions in the field', as in the first sentence above.

A north-seeking pole (north pole or N-pole) is attracted approximately in the direction of geographical North; a southseeking pole (south pole or S-pole) tends to move towards geographical South. Magnetic poles can only be found in opposite (unlike) pairs. The Earth's magnetic poles—regions where the Earth's field is strongest—are close to the geographical poles.

Pole Strength. The force exerted by a given magnetic pole when it is one metre from a unit pole in a vacuum. A unit pole is defined as that pole which, when placed one metre from a similar pole in a vacuum, exerts a force of one newton.

Pole Face. An end surface of the core of a magnet, through which surface passes the useful magnetic flux.

Pole Piece. Either of the pieces of ferromagnetic material attached to the ends of a permanent magnet or electromagnet in an electric device.

Polychromatic Radiation. Electromagnetic radiation that has a mixture of different wavelengths.

Polygon of Forces. A polygon in which the sides represent, in magnitude and direction, all forces acting on a rigid body. If such a polygon can be constructed, taking the forces in order, the body will be in equilibrium.

Polymorphism. The existence of different structural or crystalline forms of the same chemical compound. It is sometimes known as allomorphism. The choice of the form taken depends largely on temperature and pressure.

Polytropic Change or Process. Refers to any process involving the compression or expansion of a constant mass of gas. All such changes are reversible and can be represented on a pressure-volume graph by a family of curves $PV^n =$ constant, where P is the pressure, V the volume, and n may take any positive value between zero and infinity.

When $n=0$ the change is isobaric, when $n=1$ it is isothermal, when $n=\gamma$ (the ratio of the specific heat at constant pressure to that at constant volume) it is adiabatic, and when $n=\infty$ it is isometric.

Pomeranchuk Theorem. States that the cross-sections of particles and anti-particles of the same type incident on the same target particle should approach the same, constant, value as the incident energy becomes very large.

Population. A term used in statistics to refer to the situation under consideration, whether or not a collection of people is involved.

Population Type. A method of classifying stars as either population I or population II bodies, devised in 1944 by Wilhelm Baade (1893—1960). Population I stars are the young metal-rich highly luminous stars found in the spiral arms of galaxies. Population II stars are older metal-deficient stars that occur in the centres of galaxies.

Porosity

(1) The property of a solid of containing pores, *i.e*, minute channels, and open or closed spaces.

(2) The proportion of the total volume occupied by such pores.

Position Angle. A measure of the orientation of one point on the celestial sphere with respect to another.

Position Line. A line on a navigational chart, obtained from observations of terrestrial or celestial objects, or from radio or radar aids, on which the position of the observer is computed to lie at the time of the observation.

Positive. Charge.

Positive Charge. The type of charge acquired by a cellulose acetate rod when it is rubbed with a cloth.

Positive Column. A luminous area in an electrical discharge in a gas, occurring near the positive electrode.

Positive Electron. Another name for Positron.

Positive Feedback. Feedback.

Positive Lens. A lens with a positive power.

Positive Mirror. A curved mirror with a positive power.

Positive Pole. A magnetic N-pole.

Positive Rays. Streams of positive ions in an electrical discharge.

Positron. The antiparticle of the electron; a particle with the same mass as the electron but with a positive charge. Positrons are found in cosmic-ray showers, where they result from pair production. They are also produced by a type of beta decay. They are annihilated when they encounter an electron, so have a short separate existence. Positrons can be detected by their tracks in cloud or bubble chambers, where they show the opposite deflection to electrons in a magnetic field.

Positronium. An electron-positron pair. If the particle spins are parallel it is known as an orthopositronium and as a parapositronium if the spins are antiparallel. The mean life of the former is about 10^{-7} second and it decays to three photons; for the latter the mean life is less than 10^{-7} second and it decays to two photons.

Post-acceleration. In an electron beam tube : the acceleration of the electrons after deflection.

Post Office Box. A box containing resistances that can be switched into the circuit, suitable for use as a Wheatstone bridge or potentiometer.

Potassium-argon Dating. A dating technique for certain rocks that depends on the decay of the radioisotope potassium—40 to argon—40, a process with a half-life of about 1.27×10^{10} years. It assumes that all the argon—40 formed in the potassium-bearing mineral accumulates within it and that all the argon present is formed by the decay of potassium—40. The mass of argon—40 and

potassium—40 in the sample is estimated and the sample is then dated from the equation :

$$^{40}Ar = 0.1102\ ^{40}K(e^{\lambda t} - 1)$$

where λ is the decay constant and t is the time in years since the mineral cooled to about 300°C, when the ^{40}Ar became trapped in the crystal lattice. The method is effective for micas, feldspar, and some other minerals.

Potential. A term used in a variety of contexts to denote the work necessary to move a unit of a particular quantity from infinity to the point in question. In the case of electrostatic potential the quantity is electrostatic, *i.e.* unit charge. With magnetostatic potential the quantity is magnetostatic, *i.e.* unit pole, and with gravitational potential it is gravitational, *i.e.* unit mass. Gravitational potential is always negative but electrostatic and magnetostatic potential may be positive or negative. Potential is a Scalar quantity and is a function only of the position of the point considered, since only conservative force fields are involved.

Potential Barrier. A region containing a maximum of potential that prevents a particle on one side of it from passing to the other side. According to classical theory a particle must possess energy in excess of the height of the potential barrier to pass it. However, in quantum theory there is a finite probabliity that a particle with less energy will pass through the barrier (tunnel effect). A potential barrier surrounds the atomic nucleus and is important in nuclear physics; a similar but much lower barrier exists at the interface between semiconductors and metals and between differently doped semiconductors. These barriers are important in the design of electronic devices.

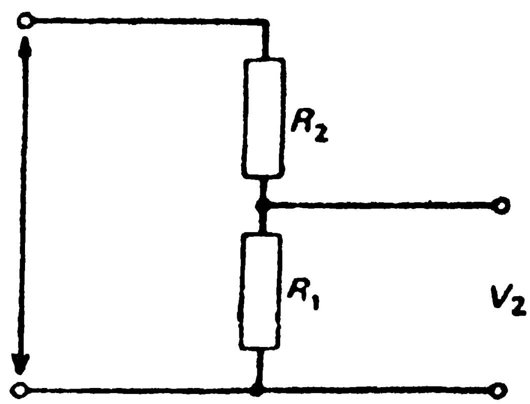
Potential Depression. A region of low potential in a field of force.

Potential Difference. The difference in electrical potential between two points.

Potential Difference (p.d.) Symbol : V. The difference in electric potential between two points in an electric field or in an electric circuit. The energy transferred, in joules, in taking Q coulombs of charge across a p.d. of V volts is $W=QV$, regardless of the path taken.

Potential Divider. A circuit, illustrated in fig. used to obtain a known fraction of an applied voltage V. This voltage is connected across a chain of resistors connected is series; only two are shown but the same principle applies. Tapping as shown gives a voltage V_2 across R_1 of

$$R_1V/(R_1+R_2)$$



Potential divider

Potential Energy Symbol : V The work an object can do because of its position or state. There are many examples. The work an object at height can do in falling is its gravitational potential energy. The energy 'stored' in elastic or a spring under tension or compression is elastic potential energy. Potential difference in electricity is a similar concept, and so on. In practice the potential energy of a system is the energy involved in bringing it to its current.

Potential Energy Curves and Surfaces. Curves and surfaces depicting the potential energy of two or more atoms as a function of coordinates describing their relative positions.

Potential Function

1. A function which satisfies Laplace's equation $\Delta^2\psi=0$.

2. A scalar function which describes the forces acting on any particle of a conservative system. It satisfies the equation $F = -\nabla V$, where F is the resultant force vector and V the potential function.

Potential Gradient. The rate of change of potential in the direction giving a maximum value.

Potential Scattering. Of a particle by an atomic nucleus: scattering in which the incident particle is considered to be reflected at the surface of the nucleus as though the latter were a hard sphere.

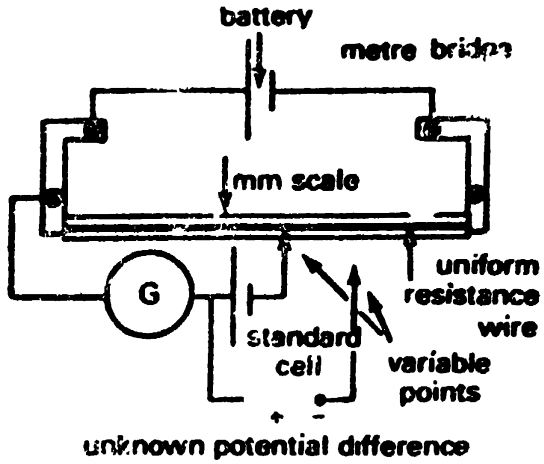
Potential Transformer : Voltage Transformer. A transformer whose primary winding is connected to the main circuit and whose secondary winding to in instrument, *e.g.* a voltmeter. It permits instruments to be isolated from a high voltage supply and is used to extend their range.

Potential Well. A region in a field of force surrounded by a higher potential region, the transition between the two being abrupt.

Potentiometer. An instrument for measuring electrical potential differences by balancing two opposing potentials so that no current flows through a galvanometer. A standard reference cell with a known e.m.f. is connected across the ends of a uniform resistance wire. The unknown e.m.f. is tnen connected, so that it opposes the e.m.f. of the standard cell, between one end, A, of the wire and a sliding contact that can move along the wire. A galvanometer is connected in series with this cell.

When the position of the contact is adjusted to make the reading on the galvanometer zero, the length of wire from A to the contact, divided by the total length, is equal to the ratio of the unknown e.m.f. to that of the reference cell. This is a very accurate method because no current flows across the potential being measured.

Potentiometers are used to compare two e m.f.s. by balancing each in turn against the reference cell. They can also be used to measure current, by measuring the



Potentiometer

potential drop across a standard resistor. Another application is in comparing two resistances by measuring the potential difference across each in turn when the same current flows through them.

Potentiometric. Denoting an experimental technique which depends on measurements of potential. Thus a potentiometric titration is one in which the end point is determined by following the electrode potential of an electrode in the mixture.

Potentiostat. A device for the automatic maintenance of the potential of an electrode in an electrolyte while conditions in the electrolyte or at the surface of the electrode are changing.

Potter-bucky Diaphragm. A device incorporating a moving grid which, while collimating an X-ray beam, eliminates grid shadows from a radiograph.

Pound. An Imperial unit of mass. Formerly, it was defined as the mass of a platinum prototype. In 1963 the definition was changed to 0.453 592 37 kilogram.

Poundal. The unit of force in the f.p.s. system of uuits equal to the force required to impart to a mass of one pound an acceleration of one foot per second per second.

Pound Force. Symbol lbf. A unit of force.

Pound Weight. A unit equal to g Poundal where g is the local acceleration due to gravity measured in feet per second. It differs from the Pound Force in that the standard rather than the local value of the acceleration due to gravity is used for the pound force.

Powder Method. In crystal structure analysis : the examination of polycrystalline material by X-ray, electron, or neutron diffraction. The diffracted beams may be detected, and their positions and intensities measured, either photographically (as in an X-ray powder camera) or by means of a diffractometer.

Powder Pattern

1. The pattern recorded by an X-ray powder camera.
2. A Bitter figure, or magnetic powder pattern.

Powder Photography. An X-ray Analysis method in which the specimen is a randomly orientated crystalline powder.

Power (focal power). Symbol : P A measure of the ability of a lens or mirror to converge a parallel beam, given by the reciprocal of the focal distance f.

$$P=1/f$$

Generally, f is in metres in which case P is in dioptres (D).

Strictly, power measures the ability of a reflecting or refracting surface, or of a lens, to change the curvature of incident wave fronts. The dioptre is better called the radian per metre (rad m^{-1}).

Power Symbol : P The rate of energy transfer (or work done) by or to a system. The unit of power is the watt—the energy transfer in joules per second. In an electrical

system power is given by VI, where V is the potential difference across a conductor and I the current through it. If V and I are not in phase the power absorbed is IVcos ϕ, where ϕ, the phase angle, is known as the 'power factor'.

Power Amplification. The ratio of the power at the output terminals of an amplifier to that at the input terminals.

Power Amplifier. An amplifier that delivers useful amounts of power to a load such as a speaker or antenna. The prime function of this device is to produce maximum output power. Due to transistor operation limitations (such as maximum current, voltage, and power dissipation ratings), the conditions for maximum power gain do not necessarily coincide with those for maximum power output. The maximum power dissipation rating of a transistor is very important in the operation of a power amplifier, for it is this rating that limits the power output obtainable from any specific transistor.

For all practical purposes, the schematic diagram of a power amplifier is similar to that of any low-power or medium-power power amplifier, with the major difference being the higher power rating, large physical construction, and mounting methods of the power transistor. One other difference is that the power amplifier, being designed for maximum output power rather than maximum gain, will usually have a much smaller value of load impedance than the preceding stages.

Power Factor. The ratio of the true power to the apparent power in an alternating current circuit, the apparent power being the product of the Root Mean Square voltage and the root mean square current in the circuit.

Power Gain. The ratio of power at some point in the radiation field of an antenna over the power at the same point of a single-dipole antenna located in the same position and fed in the same way as the antenna being measured.

An antenna with high directivity has a high power gain, and vice versa. The power gain of a single dipole with no reflector is one. An array of several dipoles in the same position as the single dipole and fed with the same line would have a power gain of more than one, with the exact figure depending on the directivity of the array.

Power Loss. Power dissipated as heat in a dielectric on account of its finite conductivity.

Power of Accommodation. The change in power of the Eye due to alteration in the focal length of the crystalline lens, which is produced by changes in ciliary muscle tension. The maximum power of accommodation of the human eye is about 4 dioptre.

Power Output. Identified by the symbol P_0, the power deliverable by an amplifier, generator, or other circuit into a specific load. Output power is usually measured in watts and is divided into the total power output to arrive at an overall power efficiency rating. For instance, an amplifier delivers 100 W of power to the load and the power consumed at the input is 150 W.

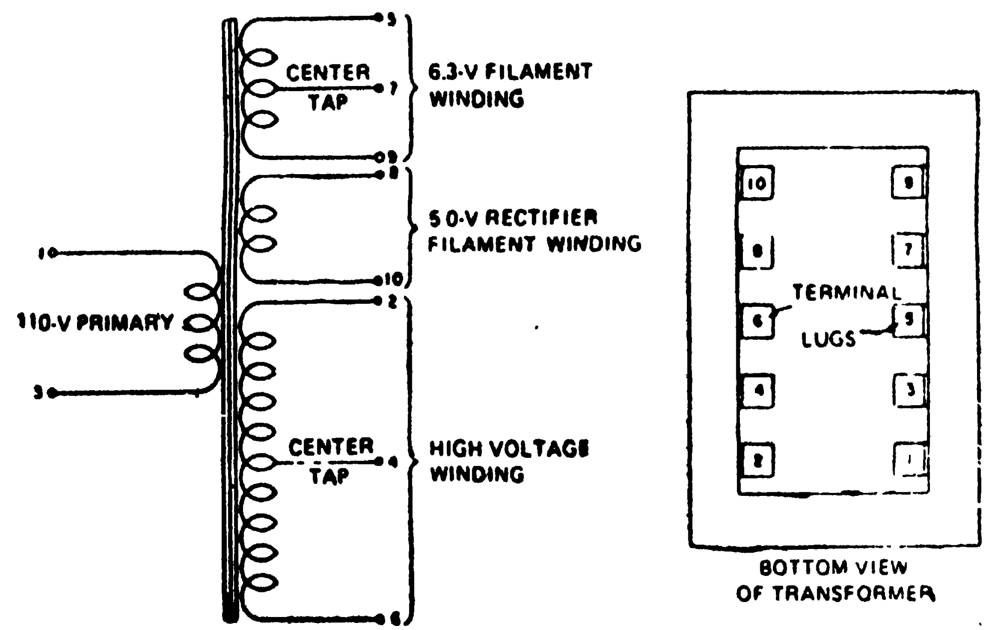
Power efficiency is equal to 100 divided by 150, or 6.66 per cent.

Power Pack. A circuit supplying power to another circuit. For maximum efficiency the electric Impedance of each circuit should match.

Power Rating. Measured in watts, an indication of the rate at which a device converts electrical energy into another form of energy, such as light, heat, or motion. An example of such a rating is noted when comparing a 150-W lamp to a 100-W lamp The higher wattage rating of the 150-W lamp indicates that it is capable of converting more electrical energy into light energy than the lamp of the lower rating. Other common examples of devices rated in this manner are soldering irons and small electric motors.

Power Reactor. A nuclear reactor designed to produce electrical power.

Power Transformer. A device designed to change an ac voltage or a periodically varying dc voltage from one value to another without any change in frequency. A power transformer is shown in Fig. It consists of a primary winding connected to the source of energy, a laminated iron core, and one or more secondary windings. Theoretically, any winding may be used as the primary, provided the proper voltage and frequency are applied to it. The laminated iron core serves as an efficient means of



A power transformer.

magnetically coupling together the primary and secondary windings.

A periodically varying voltage applied to the primary winding produces a varying current that, in turn, develops a varying flux in the iron core. This varying flux cuts all windings, inducing in each of them a voltage proportional to the number of turns.

The ratio of the primary voltage to any secondary voltage is practically equal to the ratio of the primary

turns to the secondary turns, as indicated by the formula

$$\frac{E_p}{E_s} = \frac{N_p}{N_s}$$

The voltage induced in the primary winding by the growing and dying core flux is practically equal to the applied voltage. Moreover, this induced voltage directly opposes the applied voltage. Therefore, the current drawn from the supply is small.

When a secondary circuit is completed, current circulates around the iron core in the opposite direction to the primary current, reducing the core flux and the counter voltage of the primary. This action causes the current in the primary to vary in accordance with the secondary load. It is through this action that the transformer automatically adjusts itself to changes in secondary load.

Power Transistor. A transistor dissipating more than about 1 watt. Such transistors are used for switching and amplification. For the higher powers they require some form of temperature control.

Poynting's Theorem. The rate of energy transfer from Electromagnetic Radiation is proportional to the product of the electric and magnetic field strengths associated with the radiation.

Poynting Vector. The Vector Product of the electric and magnetic field strengths at any point. Its surface integral thus gives the rate of energy transfer from electromagnetic radiation associated with the fields.

Poynting Vector Symbol : S the vector product of the electric field vector E and the magnetic field vector B in an electromagnetic wave. The Poynting vector gives, in magnitude and direction, the power radiated through unit area at any instant. The unit is the watt per square metre. The average value is give by $\frac{1}{2}E_0B_0$, E_0 and B_0 being the amplitudes of E and B.

Prandtl-meyer Expansion. An expansion wave produced at a corner by a homentropic two-dimensional supersonic flow.

Prandtl Number. A dimensionless number given by the ratio of the kinematic viscosity to the diffusivity. If expresses the ratio of the diffusivity of momentum to that of temperature through a fluid.

Preamplifier. An amplifier in a radio, record player, etc., providing a first stage of amplification. It is usually located close to the signal source (*i.e.* the aerial or pick-up) and the signal is then transmitted by cable to the main amplifier. Preamplification at this early stage improves the signal-to-noise ratio of the whole system.

Precession. If a body is spinning on an axis, the axis of rotation can itself move around another axis at an angle to it. The effect is seen in gyroscopes. It also occurs for closed orbits (*e.g.* of a planet), in which the whole orbit moves around an axis.

Precessional Motion. A form of motion that occurs when a torque is applied to a rotating body in such a way that it tends to change the direction of its axis of rotation. It arises because the resultant of the angular velocity of rotation and the increment of angular velocity produced by the torque is an angular velocity about a new direction; this commonly changes the axis of the applied torque and leads to sustained rotation of the original axis of rotation.

A spinning top, the axis of which is not exactly vertical, has a torque acting on it as a result of gravity. Instead of falling over, the top precesses about a vertical line through the pivot. The earth also experiences a torque and undergoes a slow precession, primarily as a result of the gravitational attraction of the sun and the moon on its equatorial bulge.

Precession of the Equinoxes. The slow westward motion of the equinoxes about the ecliptic as a result of the earth's

precessional motion. The equinoxes move round the ecliptic with a period of 25 800 years.

Predator Prey Relations. An example of an automatic type of Feedback system : if predators increase, prey are killed off faster and so their numbers diminish. Predators then cannot find sufficient food and so they die or move. The prey population then increases and so the cycle is maintained.

Preferred Orientation. Of crystallites : the arrangement of the crystallites in a polycrystalline material in such a way that one, two, or three of their crystallographic directions each tend to be parallel to identifiable directions related to the shape or macrostructure of the material. Where only one direction is involved we have a fibre structure; where two are involved we have parallel planes in the material, as in a layer lattice; and where three directions are involved we have an approximation to a single crystal.

Preionization. In spectroscopy: the decomposition of an excited molecule into ionized atoms without emitting radiation.

Presbyopia. A defect of the Eye in which near objects cannot be focused clearly. It is caused by hardening of the eye's crystalline lens so that the ciliary muscle cannot increase its power sufficiently. The defect can be corrected by wearing convex spectacle lenses for close work.

Pressure. The force acting on unit area of a surface or the ratio of force to area. It is measured in pascals in SI units. Absolute pressure is pressure measured on a gauge that reads zero at zero pressure rather than at atmospheric pressure. Gauge pressure is measured on a gauge that reads zero at atmospheric pressure.

Pressure Accumulator. A hydraulic device in which a suitable fluid in compressed and stored for future use.

Pressure Balance. An instrument for the measurement of high pressures in which the fluid pressure acting on a vertical piston of known effective area is balanced by a load derived from accurately calibrated weights.

Pressure Broadening. The increase in the width of a spectral line resulting from collisions between atoms or molecules. It relates to pressure, as there are more collisions at high pressure.

Pressure Coefficient. The coefficient of pressure increase with absolute temperature of a gas at constant volume. It is given by

$$(p-p_0)/[p_0(T-273)]$$

where p and p_0 are the pressures at temperatures T K and 273 K respectively. It has practically the same value of $1/273\ K^{-1}$ for all gases.

Pressure Gauge. An instrument for measuring pressure. In primary gauges the pressure is balanced against a known force. For example in the liquid column Manometer, the pressure difference between two gases above the liquid, density ρ, in the arms of a U tube is given by $g\rho h$ where h is the difference of height in the two arms and g is the acceleration due to gravity. The Mcleod Gauge is another primary gauge example. Secondary gauges depend on the measurement of some physical property that varies with pressure. Examples are the Pirani Gauge and the Ionization Gauge.

Pressure Head. The head, *i.e.* height of liquid, capable of exerting a given pressure.

Pressure of the Atmosphere. The pressure at a point near the Earth's surface due to the weight of air above that point. Its value varies around about 100 kPa (100 000 newtons per square metre). Barometers are used to measure atmospheric pressure which is important because the small changes relate to imminent weather changes.

Because the pressure at depth in a fluid depends on depth, barometers can be used as altimeters; they can be marked to indicate distance above or below sea level.

Pressure Transducer. A device using pressure to give some sort of signal which is then converted into another type of signal, often electric. For example in an electromanometer the deformation of the transducer element, under the action of pressure, is transformed into an electric signal which is amplified and recorded.

Pressurized-water Reactor (PWR). A nuclear reactor in which water, used as moderator, coolant, and reflector, is kept under pressure to prevent it from boiling at the operating temperature. The core is of 3% enriched uranium. This type of reactor has been used in nuclear powered submarines from 1954 onwards.

Prevost's Theory of Exchanges. The theory that all bodies emit and absorb radiation continuously. The rate of emission depends on the body's surface and its temperature. The rate of absorption depends on the surface and the temperature of the surroundings. When the temperature of a body is constant, it is losing and gaining energy at equal rates, and is in equilibrium with its surroundings. If there is a temperature difference, there is a net flow of energy (heat).

Primary

1. The body around with another body orbits. Thus in the solar system the Sun is the Earth's primary.
2. Short for Primary Winding.

Primary Cell. A voltaic cell in which the chemical reaction producing the e.m.f. is not satisfactorily reversible and the cell cannot therefore be recharged by the application of a charging current.

Primary Colours. A set of three coloured lights (hues) that when mixed together in the right proportions, give the

sensation of white. Normally the hues are chosen from the red, green, and blue regions.

An infinite number of sets of primary hues exists. The standard choice is one of convenience. According to the trichromatic theory of colour any set of three primary colours has only one requirement—no one of them can be matched by mixing the other two.

Primary Electrons. Electrons incident on a substance from which they may release secondary electrons.

Primary Ionization. In the path of an ionizing particle : the ionization formed directly in the interactions of the particle with the atoms of matter traversed.

Primary Radiation. Radiation emerging directly from a source of the radiation concerned.

Primary Winding. The winding on the input side of a transformer or induction coil. Compare secondary winding.

Principal Axis (axis). The line joining the centres of curvature of the faces of a lens, or the line normal to a reflector at the pole.

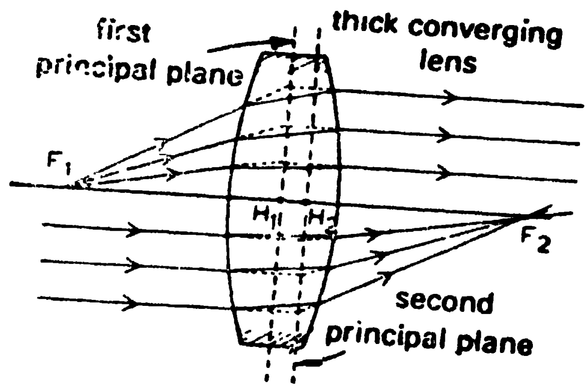
Principal Focus. A point through which rays close to and parallel to the axis of a lens or spherical mirror pass, or appear to pass, after refraction or reflection. A mirror has one principal focus, a lens has a principal focus on both sides.

Principal Point. Either of two points on the principal axis of a thick lens from which simply related distances can be measured, as from the optical centre of a thin lens.

Principal Refractive Indices. Of a doubly refracting crystal : the refractive indices corresponding to the principal vibration axis.

Principal Vibration Axes Of a doubly refracting crystal : the directions corresponding to the fastest and slowest vibrations, together with the direction at right angles to these vibrations.

Principal Plane. The plane perpendicular to the principal axis of a lens centred on the pole (optical centre). The pole is equidistant between the principal focal points. This is strictly true only for a thin lens. A thick lens has two principal planes; each is centred on a principal point. The focal distance of a thick lens is the distance between each focal point and the principal point on that side of the lens.



F_1 first focal point
F_2 second focal point
H_1 first principal point
H_2 second principal point
F_1H_1=first focal distance=f
F_2H_2=second focal distance=f
Principal plane

Principle of Superposition. When two (or more) waves of the same type pass through the same region, the amplitude of vibration at any point is the algebraic sum of the individual amplitudes. Sign (crest or trough) must be taken into account. The waves emerge from the region of superposition unaffected.

Principal Points. Centred Optical System.

Principle of Moments. When an object or system is in equilibrium, the sum of the moments in any direction equals the sum of the moments in the opposite direction. Because there is no resultant turning force, the moments of the forces can be measured relative to any point in the system or outside it.

Printed Circuit. An electronic circuit consisting of a conducting material deposited (printed) onto the surface of an insulating sheet. These devices are now common in all types of electronic equipment, facilitating batch production and eliminating the unreliability of the hand-soldered joint.

Prism

1. (in mathematics) A polyhedron with two parallel congruent polygons as bases and parallelograms for all other faces. A triangular prism has triangular bases.

2. (in optics) A block of glass or other transparent material, usually having triangular bases. Prisms have several uses in opticle systems : they can be used to deviate a ray, to disperse white light into the visible spectrum, or to erect an inverted image (binoculars). Prisms of other materials are used for different kinds of radiation.

Prismatic. Denoting an optical instrument using one or more prisms.

Prism Binoculars. Binoculars.

Prismatic Colours. Colours produced when daylight is dispersed by a prism.

Prism Dioptre. Symbol P. A quantity defined by the equation

$$P=100 \tan \theta$$

where θ is the angle of deviation produced by a Thin Prism.

Prism, Optical. An important component of many optical systems : a block (usually of glass for work with visible radiation) with two nonparallel sides. Prisms are often triangular in section. Prism action depends on two successive refractions, each with deviation (bending) in the same direction. This is effective, for instance, in spreading different wavelengths into a spectrum. Many

prisms have been designed for special purposes for use in optical instruments.

Probe. A resonant conductor inserted into a Wavelength or Cavity Resonator in order to either inject or extract energy.

Progressive Wave. A disturbance, either continuous or transient, which travels through a medium or space. The resulting displacements of the medium are small and the medium returns to its initial state after the disturbance, has passed.

Projective. An object falling freely in a gravitational field, having been projected at a speed v and at an angle of elevation θ to the horizontal. In the special case that $\theta=90°$, the motion is linear in the vertical direction. It may then be treated using the equations of motion. In all other cases the vertical and horizontal components of velocity must be treated separately. In the absence of friction, the horizontal component is constant and the vertical motion may be treated using the equations of motion. The path of the projectile is an arc of a parabola.

Useful relations are :

time to reach maximum height

$$t=v\sin\theta/g$$

maximum height

$$h=v^2\sin^2\theta/2g$$

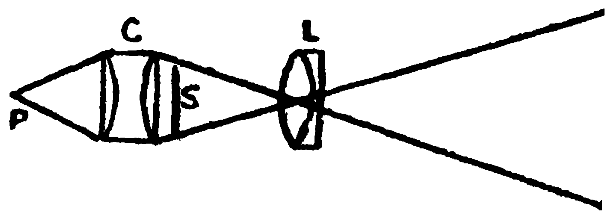
horizontal range

$$R=v^2\sin2\theta/g$$

Note that similar treatment can be applied to the case of an electric charge projected into an electric field.

Projector. An optical instrument used for showing slides on a screen; its essential features are shown in fig. The slide S is placed in front of condensing lens C. This lens forms an image of bright point source P at the objective lens L so that the maximum amount of light passes through L, L is of short focal length, in the range 10-20 centi-

metre, so that a highly magnified image of the slide is obtained on screen A.



Projector

Prominence. An eruption of gas in the Sun's upper Chromosohere, causing matter to be ejected into space in vast streamers. Many prominences appear to stand motionless over long periods; these have Sunspot associations.

Prompt Neutron. A neutron produced in a Nucleus Reactor by primary fission rather than by decay of a fission product.

Prong. In a cloud or bubble chamber or in a nuclear emulsion.

Proof Plane. A small shaped piece of foil with an insulating handle, used (often with an electroscope) to investigate the distribution of charge on the surface of an object.

Propagation Loss. The energy loss due to absorption, scattering and beam-spreading from a beam of electromagnetic radiation.

Propellant

(1) The fuel, including the oxidant, used in a space rocket.

(2) The explosive charge used to fire a bullet or shell.

(3) An inert gaseous substance, liquefied under pressure, used to expel the contents of an aerosol can.

Proper Motion. The apparent angular motion of a star on the celestial sphere. This is motion in a direction that is perpendicular to the line of sight.

Proper Value. Anglicized form of eigenvalue.

Proportional Counter. A counter for ionizing radiation in which the potential difference applied is high enough for multiplication of ions, so that the height of the pulse is proportional to the number of ions produced by the particle, and thus to its energy loss. A counter used in this way is said to be in the proportional region.

Proprioceptor. An organ found in all skeletal muscles. Its function is to sense what is happening in the muscle and report back to the central nervous system, using electric impulses. If appropriate, electric signals to change the action are then transmitted back to the muscle. The system thus effectively employs negative Feedback.

Proportional Limit. Elasticity.

Proportional Region. Proportional counter.

Prestar. Stellar evolution.

Protective Relay. A Relay that causes the opening of a Circuit-Breaker in order to disconnect faulty apparatus from the supply and thus protect the apparatus from the damaging effects of overloads and internal faults.

Proton. A stable positively charged Elementary Particle. Protons are responsible for the charge on a nucleus: the nucleus of the hydrogen atom is a proton and all other nuclei contain protons. The proton charge has the same magnitude as the electronic charge. The rest mass of the proton is

$$1.672\,62 \times 10^{-27} \text{ kilogramme}$$

Proton Magnetometer. A precise and portable instrument, based on the phenomenon of the free precession of atomic nuclei (specifically protons), which is mainly used for the rapid measurement of the total intensity of the geomagnetic field. It can only function when remote from the gradients associated with iron and steel objects, and is therefore unsuitable for use within the laboratory, although eminently suitable as a field surveying instrument.

One interesting application is to the detection of buried archaeological remains.

Proton Microscope. A device similar to the Electron Microscope but using a beam of protons instead of electrons. This results in better resolving power and contrast.

Proton Number (atomic number). Symbol : Z The number of protons in the nucleus of an atom. The proton number determines the chemical properties of the element because the electron structure, which determines chemical bonding, depends on the electrostatic attraction to the positively charged nucleus.

Proton-proton Chain Reaction. A series of nuclear fusion reactions by which hydrogen is converted into helium. It is thought that the reactions are responsible for energy production in the Sun and similar stars. There are in fact three possible sequences. The main one is :

$$^{1}H+{}^{1}H\rightarrow{}^{2}H+\nu+e^{+}$$
$$^{2}H+{}^{1}H\rightarrow{}^{3}He+\gamma$$
$$^{3}He+{}^{3}He\rightarrow{}^{4}He+2{}^{1}H$$

the two other sequences lead to ^{4}He also, through ^{7}Li and ^{8}Be.

Proton Radioactivity. The emission of protons from nuclei with a measurable delay. So far only one type has been observed, namely the emission of protons by excited nuclei formed in the process of β-decay. As with delayed neutrons the observed half-life is that of the β-decay of the parent nuclide. Two other types are, however, possible theoretically : potential-barrier delayed proton emission (analogous to α-radioactivity) and two-proton radioactivity.

Proton Scattering Microscopy. The imaging of a crystalline structure on, say, a fluorescent screen by the scattering of a proton beam, owing to the phenomenon of blocking, *i.e.*, the prevention of a proton beam from leaving a crystal in the direction of a close-packed row or along a

densely populated plane of atoms, owing to the obstacle presented by such a row or plane. It is to be distinguished from proton microscopy, the proton microscope being separately defined.

Proton Synchrotron. A particle accelerator of large radius, capable of accelerating protons to very high energies: 500 giga-electronvolt has been reached by an American machine. The proton synchrotron uses a varying frequency electric field in contrast to the fixed frequency one used in the Synchrotron. In other respects the machines are basically similar.

Proton Transfer Reaction. A chemical reaction which involves the transfer of a proton from one chemical species to another.

Proximity Effect. The change in current distribution in a conductor, with related changes in resistance and capacitance, due to the field produced by an adjacent conductor.

Psi Particle (J particle). A meson discovered in 1974, which led to the extension of the quark model and the hypothesis that a fourth quark existed with the property of charm (elementary particles). The psi particle is believed to consist of a charmed quark and its antiquark.

Psychrometer. A hygrometer consisting of a similar pair of thermometers, the bulb of one of which is kept wet, and therefore cooled by evaporation. The difference in temperature between the two thermometers is a measure of the relative humidity of the air.

Psychrometric Tables. Tables from which the relative humidity, and sometimes other quantities such as the dew-point temperature, can be derived from wet-and dry-bulb temperatures.

Psychrometry. The measurement of atmospheric humidity.

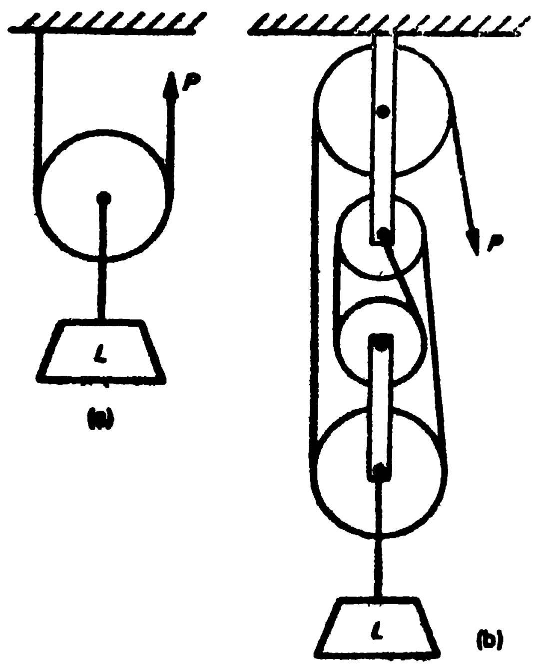
Ptolemaic System. A system based on the concept that the components of the universe, such as the Sun, Moon etc.,

revolved around the Earth. It was superseded by the Copernican System.

P-type Conductivity. Conductivity produced in a Semiconductor by a flow of Holes.

P-type Semiconductor. An extrinsic Semiconductor in which the mobile Hole density exceeds that of conductionband electrons.

Pulley. A simple machine consisting of a wheel with a flat, crowned, or grooved rim to take a belt, rope, or chain with which a load can be raised.



Pulleys

In fig (a), assuming the system is frictionless, the force P in any part of the rope is constant, therefore $2P=L$, where L is the load. In general, $nP=L$, where n is the number of supporting ropes. In fig (b), the number of supporting ropes is 4. The mechanical advantage of a pulley system is the ratio of the load, L, to the effort applied to the free end of the rope, P, *i.e.*, mechanical advantage$=L/P=L(L/n)^{-1}=n$. Thus in fig (b) the mechanical advantage is 4. A combination of ropes and pulleys as in fig (b) is called a block and tackle.

Pulsar. A celestial source of radiation emitted in brief (0.03 second to 4 seconds) regulae pulses. First discovered in 1968, a pulsar is believed to be a rotating neutron star. The strong magnetic field of the neutron star concentrates charged particles in two regions and the radiation is emitted in two directional beams. The pulsing effect occurs as the beams rotate. Most pulsars are radio sources (emit electromagnetic radiation of radio (frequencies) but a few that emit light or X-rays have been detected. Over 300 pulsars are now known, but it is estimated that there are over one million in the Milky Way.

Pulsating Current. A unidirectional current of regularly varying magnitude.

Pulsating Star. A star radiating with variable intensity due to regular volume variations in its surface atmosphere.

Pulse. A sudden disturbance propagated as a wave, singly, or in a train, or applied to a mechanical system capable of movement.

Pulse Amplifier. An amplifier designed to amplify, and sometimes to shape, random pulses, *e.g.*, pulses from a radiation detector, or carrier frequency pulses.

Pulse Analyser. An instrument for recording the variation of blood pressure during heart beats by measuring the periodic displacement produced in the walls of veins and arteries.

Pulse Generator. A generator of electrical pulses frequently of very short duration, *e.g.*, microseconds. Such generators are in general of two types : those that produce a pulse in response to an initiating signal (known as trigger circuits), and those that give out a train of regularly spaced pulses (known as free-running generators).

Pulse Height Analyser. An electronic circuit for sorting voltage impulses according to their amplitude.

Pulse-height Discriminator. A circuit which accepts only those electrical pulses having amplitudes greater than a preset level and produces an output pulse of fixed amplitude (and sometimes of fixed width) for each pulse accepted. The circuit is also known as a pulse-amplitude discriminator.

Pulse-height Selector. A circuit which permits only those electrical pulses that have amplitudes lying between predetermined levels to be passed to the succeeding circuits. It is normally part of a single-channel pulse-height analyser. The circuit is also known as a pulse-amplitude selector.

Pulse-interval Analyser. A device for counting the number of events (*e.g.*, for particle time-of-flight measurements or for observations of radioactive processes) occurring in each of a sequence of uniform time intervals.

Pulse Jet. A type of ramjet (jet propulsion) in which a louvred valve at the front of the projectile is blown open by the ram effect of the moving projectile and remains open until pressure has built up in the combustion chamber. Fuel is then admitted and the mixture exploded by spark ignition. This closes the louvred valve and produces thrust at the open rear end of the projectile. The German flying bombs of World War II were powered by pulse jets.

Pulse Modulation. Modulation in which information is transmitted by controlling the amplitude, duration, position or presence of a series of electric pulses.

Pulse Radiolysis. A tachnique used in radiochemistry whereby high instantaneous concentrations of chemically reactive species are produced in liquids by a short (2-10 μs) intense pulse of electrons from a linear accelerator. The transient intermediates and the subsequent reactions are commonly identified and followed by absorption spectroscopy.

Pulse-shape Discrimination. A technique for examining the shape of an electrical pulse in the circuit of a radiation detector so as to yield information as to the nature of the initiating event, such as the type of particle entering the detector or the position at which that event occurred.

Pump. A device that imparts energy to a fluid in order to move it from one place or level to another or to raise its pressure (compare vacuum pump). Centrifugal pumps and tubines have rotating impellers, which increase the velocity of the fluid, part of the energy so acquired by the fluid then being converted to pressure energy. Displacement pumps act directly on the fluid, forcing it to flow against a pressure. They include piston, plunger, gear, screw, and can pumps.

Pupil. The aperture of the eye, adjustable in size by the circular iris muscle. The pupil appears black as very little incident light is reflected by the retina.

Pupilometer. An instrument for measuring the size and shape of the pupil of the eye and its position relative to the iris.

Pure Note (pure tone). Note.

Pure Spectrum. A spectrum in which the various images of the source slit (Spectrometer) do not overlap, *i.e.*, they are monochromatic.

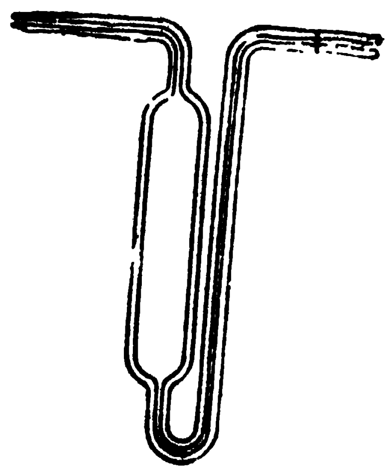
Purkinje Effect. The shift in the spectral sensitivity of the eye from the yellow—green, at a good level of ililuminaton, towards the blue, as the illumination is reduced.

Push Button. A small type of switch actuated by finger pressure. Typical examples include doorbells, elevator controls, and the like.

PWR. Pressurized-water reactor.

Pyknometer. A glass device, illustrated in fig., used for measuring liquid relative density. The liquid is sucked into the tube until it reaches the graduation mark, thus giving a precise volume of liquid whose mass is found in

the usual way. The technique described for the Relative Density Bottle is then followed.



Pyknometer

Pyrgeometer. An instrument for measuring the loss of heat by radiation from the Earth.

Pyroelectricity. The property of certain crystals, such as tourmaline, of acquiring opposite electrical charges on opposite faces when heated. In tourmaline a rise in temperature of 1 K at room temperature produces a polarization of some 10^{-7} Cm^{-2}.

Pythagorean Scale. A musical scale in which the frequency inrervals are represented by the ratios of integral powers of 2 and 3.

Pyrometer. An instrument for measuring high temperatures, often at a distance.

The optical pyrometer determines the temperature of a radiant source from the colour of the radiation. The colour may be judged by eye, but is generally matched with that of a standard radiator, such as a heated filament, whose temperature can be varied.

The colour pyrometer is a type of optical pyrometer in which a calibrated wedgeshaped filter transmits only

red and green light. The temperature is obtained from the wedge setting where the source appears white.

The radiation pyrometer is a pyrometer in which thermal radiation from the hot body is focused on a sensitive Thermocouple whose electromotive force is measured.

The thermocouple pyrometer permits direct measurement of a temperature by immersing a Thermocouple in the hot substance.

Pyrometry. The measurement of high temperatures (beyond the range of themometers) using a pyrometer. Modern narrow-band or spectral pyrometers use infrared-sensitive photoelectric cells behind filters that exclude visible light. In the optical pyrometer (or disappearing filament pyrometer) the image of the incandescent source is focused in the plane of a tungsten filament that is heated electrically. A variable resistor is used to adjust the current through the filament until it blends into the image of the source, when viewed through a red filter and an eyepiece. The temperature is then read from a calibrated ammeter or a calibrated dial on the variable resistor. In the total-radiation pyrometer radiation emitted by the source is focused by a concave mirror onto a blackened foil to which a thermopile is attached. From the e.m.f. produced by the thermopile the temperature of the source can be calculated.

Pyrophoric. Igniting spontaneously in air. Pyrophoric alloys are alloys that give sparks when struck.

Q

Q : Q-value. Of a given system, process, or phenomenon : a term used to denote a measure of the energy balance. It is often used as a figure of merit. Thus, for a resonant system (*e.g.* an electrical circuit) it is ($2\pi \times$ energy stored)/(energy lost per cycle); for a system in forced vibration it is the amplitude magnification factor at resonance, and its reciprocal is a direct measure of the damping capacity; for a given nuclear disintegration it is the amount of energy released in that disintegration; and for a nuclear reaction it is the difference in total kinetic energy between the particles leaving and entering the reacting system.

QCD. Abbrev. for Quantum Chromodynamics.

QED. Abbrev. for Quantum Electrodynamics.

Q Factor. Short for Quality Factor.

QRS Complex. The variation of electric potential of the heart with time during ventricular contraction.

QSG. Quasars.

QSO. Quasars.

QSS. Quasars.

Q-switching : Q-spoiling. Of a laser : the pumping of the laser into a non-resonant mode followed by a switch into resonance. The technique was developed for use with solid-state lasers provide very high pulsed output powers, but it can also be applied to gas lasers. Typical Q-switches include the Kerr cell, rotating mirrors, and bleachable absorbers, all of which in one way or another act as optical shutters.

Quadrant. An instrument dating back to antiquity and used for measuring altitudes. It remained the most important astronomical instrument until the telescope was invented. It consisted of a 90° graduated arc (a quarter circle) with a swivelling arm to which a sighting mechanism was attached. In the mural quadrant the graduated arc, often very large, was attached to a wall and was oriented along the observer's meridian. The mural quadrant was therefore the forerunner of the transit circle.

Quadrant Electrometer. An electrometer in which a light metal vane is suspended inside four metal quadrants by a torsion wire. Opposite pairs of quadrants are connected and the potential difference to be measured is applied between the pairs. When the vane is given a potential large compared with that of the quadrants, its deflection is proportional to the quadrant potential difference. For many but not all applications the instrument is obsolescent.

Quadrature. The position of the moon or an outer planet when the line joining it to the earth makes a right angle with a line joining the earth to the sun.

Quadripole. An electric network with only four terminals, *i.e.* two input and two output terminals. If on interchange of input and output terminals the electric properties remain unchanged, the quadripole is said to be symmetrical.

Quadrupole. One of the multipoles which represent the effects, at points outside the system, of the electric and magnetic fields produced by a system of charges and currents such as those arising from the electrons in an atom or from the protons in a nucleus; and which are assumed to be located at the centre of the system. In its simplest form an electric quadrupole may be considered as an array of four equal charges positioned at the corners of a parallelogram, alternate charges being positive and negative; but more generally it is regarded as an ellipsoidal distribution of charge about the centre of the system.

Quadrupole Radiation. Radiation from an oscillating quadrupole. The quadrupole may be either magnetic or electric.

Quality

(1) The timbre of a sound, resulting from the presence of Harmonics.

(2) The fidelity of reproduction of a sound.

Quality Control. The control of the quality of manufactured products by a combination of inspection, sampling, and statistical analysis.

Quality Factor. A number assigned to a system undergoing Forced Oscillations. It is defined as 2π times the maximum energy contained in the system divided by the average energy dissipated per oscillation. The higher the quality factor, the sharper the Resonance. It is thus desirable for radio receivers to have a high quality factor since a highly selective response is required.

Quality of Sound (timber) The characteristic of a musical note that is determined by the frequencies present. It enables a listener to tell the difference between two notes of the same fundamental frequency played on different musical instruments. A pure tone has no overtones present and its waveform is a sine wave. Musical instruments produce notes that have more complex waveforms, and it can be shown that these are formed by mixing a pure tone (the fundamental) with different higher frequencies. These frequencies are simple multiples of the fundamental frequency (f); *i.e.* 2f, 3f, and so on. The fundamental together with the 'overtones' are harmonics of the note; the different contributions characterize its quality.

Quantity of Charge. The integral of electric current passing with respect to time.

Quantity of Heat Change. The product of the mass of a body

Quantization. The existence in a system, according to quantum theory, of discrete values of the parameters describing the system, in contrast to the continuous range of values permitted classically. The term is also applied to the mathematical procedures employed in calculating these values.

Quantized. A physical quantity is said to be quantized when it can only change in definite steps—it does not have a continuous range of values. To explain the photoelectric effect, for instance, the energy of the electromagnetic radiation must be quantized. Angular momentum is quantized in atoms and molecules.

Quantometer. An instrument for carrying out chemical analyses by spectroscopic methods in a semi-automatic manner, and for presenting the results directly as the percentages of the elements of interest present.

Quantum. The minimum amount by which certain properties, such as energy or angular momentum, of a system can change. Such properties do not, therefore, vary continuously, but in integral multiples of the relevant quantum. This concept forms the basis of the quantum theory. In waves and fields the quantum can be regarded as an excitation, giving a particle-like interpretation to the wave or field. Thus, the quantum of the electromagnetic field is the photon and the graviton is the quantum of the gravitational field.

Quantum Chromodynamics. A theory in particle physics describing interaction of Colour. The carriers are Gluons.

Quantum Defect. Of a spectral series: the difference for certain atoms between the total quantum number and the nearest integer.

Quantum Discontinuity. The discontinuous absorption or emission of energy which accompanies a quantum jump.

Quantum Efficiency : Quantum Yield

1. Of a photochemical reaction : the number of molecules which change in the reaction per quantum of incident light of a given wavelength.
2. Of a photocathode : the number of photoelectrons emitted by the photocathode per quantum of incident light of a given wavelength.
3. Of other reactions induced by radiation : the number of resultant events per incident quantum.

Quantum Electrodynamics. The study of the properties of electromagnetic radiation and the way in which it interacts with charged matter in terms of quantum mechanics. The collision of a moving electron with a proton, in this theory, can be visualized by a space—time diagram (Feynman diagram) in which photons are exchanged illustration.

Quantum Electronics. The application of quantum mechanics to the investigation of microwave power generation in solid crystals.

Quantum Electronic Systems. Systems having to do with atomic and molecular transitions and the interactions of atoms and molecules with electromagnetic or vibrational waves. The term includes masers, lasers, and electric and magnetic resonance phenomena.

Quantum Field Theory. A theory which utilizes appropriate operators, obeying certain commutation relations to represent all the physical observables in a system. The total energy, momentum, charge etc. of the field is built up additively from the individual contributions to each of these variables of the particles present.

Quantum Gravitation. Any of various theories of gravitation that are consistent with the theories of quantum mechanics and special relativity. It is postulated that the gravitational force between two particles is generated by the exchange of an intermediate particle. (This is similar

to the explanation of the other fundamental forces) In earlier theories the force was transmitted by the exchange of particles called gravitons of zero charge, zero rest mass, and spin 2; other particles have also been suggested.

Quantum Gravity. A quantum mechanical version of the general theory of Relativity. At present it is incomplete.

Quantum Jump. A change in a system (*e.g.* an atom or molecule) from one quantum state to another.

Quantum Limit : Boundary Wavelength. In a continuous X-ray spectrum : the shortest wavelength present. The term quantum limit is also used to denote the energy appropriate to that wavelength.

Quantum Mechanics. A system of mechanics that was developed from quantum theory and is used to explain the properties of atoms and molecules. Using the energy quantum as a starting point it incorporates Heisenberg's uncertainty principle and the de Broglie wavelength to establish the wave—particle duality (complementarity) on which Schrodinger's equation is based. This form of quantum mechanics is called wave mechanics. An alternative but equivalent formalism, matrix mechanics, is based on mathematical operators.

Quantum Metrology. The use of atomic quantum phenomena in defining and maintaining units of measurement (*e.g.* length and time) and for precision metrology and measurement in general. The use of such phenomena should enable units of measurement to be reproduced everywhere with high precision, such units being independent of material "standards", which change with time.

Quantum Number. An integer or half integer that specifies the value of a quantized physical quantity (energy, angular momentum, etc).

Quantum Optics. Optics based on the concept that light is emitted from a source in the form of discrete packets of waves called quanta or photons, which individually act like particles but which in large numbers can behave like waves. The subject is thus essentially mathematical. The analysis leads to conclusions in agreement with experimental results.

Quantum Response of Eye. A subject concerned with the minimum number n of photons necessary to stimulate a retinal receptor. The probability P that n photons will be absorbed during one flash for different values of the incident intensity I at the retina may be calculated for different values of n. The fraction of times a subject sees a light of a certain intensity I', which is proportional to I, in a number of trials is a measures of the probability of the receptors responding. As a result experimental plots of P against log I can be obtained. By comparing their shapes with ihose of the theoretical curves, n can be found. Such experiments on different subjects, using Scotopic Vision, yielded values of n in the range 1—8. It is to be noted that $n=1$ does not imply that, for this subject, a single quantum absorbed by a single receptor produced a sensation of sight, since for the optic nerve to transmit an electric implse from the retina, several receptors need to be activated. Compare Coincidence Circuit.

Quantum State. The state of a quantized system as described by its quantum numbers. For instance, the state of a hydrogen atom is described by the four quantum numbers n, l, m, m_s. In the ground state they have values 1, 0, 1, and $^1/_2$ respectively.

Quantum Statistics. A statistical description of a system of particles that obeys the rules of quantum mechanics rather than classical mechanics. In quantum statistics, energy states are considered to be quantized; if the particles are treated as indistinguishable, Bose—Einstein statistics apply and the particles are called bosons. All

known bosons have an angular momentum n, $\hbar$ where n is zero or an integer and $\hbar$ is the Planck constant. For identical bosons the wave function is always symmetric. For the particular case in which not more than one particle may appear in any of the cells into which the particles are distributed, Fermi—Dirac statistics apply and the particles are called fermions. All known fermions have a total angular momentum $(n+{}^1/_2)\,\hbar$ and any wave function that involves identical fermions is always antisymmetric.

Quantum Theory. A mathematical theory originally introduced by Max Planck (1900) to explain the black-body radiation from hot bodies. Quantum theory is based on the idea that energy (or certain other physical quantities) can be changed only in certain discrete amounts for a given system. Other early applications were the explanations of the photoelectric effect and the Compton effect and the Bohr theory of the atom.

Quantum mechanics is a system of mechanics that developed from quantum theory and is used to explain the behaviour of atoms, molecules, etc. In one form it is based on de Broglie's idea that particles can have wavelike properties—this branch of quantum mechanics is called wave mechanics.

Quantum Voltage. Of a given quantum of energy: the voltage through which an electron must be accelerated to acquire the energy corresponding to the quantum concerned.

Quark. A type of hypothetical fundamental particle postulated to make up other elementary particles. In the original theory there were three types having charges $-1/3$ or $+2/3$ the proton charge. Hadrons were formed of combinations of quarks and antiquarks. A fourth type of quark has also been postulated to explain the psi particle and the property known as 'charm'. Theoreticians have endowed quarks with other properties such as 'colour', 'flavour', 'truth', and 'beauty' to explain how

combinations of quarks can account for all the known hadrons.

Quark Confinement. The theory that there is some reason why quarks may exist inside elementary particles but not be observable in any experiment.

Quarter-wave Antenna. Any antenna that uses a main element for receiving or transmitting that is cut to an electrical quarter-wavelength at the operating frequency. To make these elements resonant, they are usually tuned against ground or a ground plane. The ground connection makes up the missing antenna element link required for resonance.

Quarter Wavelength Line. A transmission line a quarter of a wavelength long, used as an impedance matching device. The main use is in the higher ratio frequency systems.

Quarter wave Plate. A thin mica or quartz sheet cut so that its interference colour in white light is pale grey and of a thickness such that a quarter wavelength path difference is introduced between the unseparated ordinary and extra-ordinav rays into which normally incident unpolarized sodium light is split. When light which is plane polarized with its vibration plane at 45° to the principal plane of the plate is incident on the plate, circularly polarized light emergies; if the angle between the planes, differs from 45° elliptically polarized light emerges.

Quartz. The most abundant and common mineral, consisting of crystalline silica (silicon dioxide, SiO_2), crystallizing in the trigonal system. It has a hardness of 7 on the Mohs' scale. The mineral has the property of being piezoelectric and hence is used to make oscillators for clocks (quartz clock), radios, and radar instruments. It is also used in optical instruments and in glass, glaze, and abrasives.

Quartz Clock. A clock based on a piezoelectric crystal of quartz. Each quartz crystal has a natural frequency of

vibration, which depends on its size and shape. If such a crystal is introduced into an oscillating electronic circuit that resonates at a frequency very close to that of the natu ral frequency of the crystal, the whole circuit (including the crystal) will oscillate at the crystal's natural frequency and the frequency will remain constant over cosiderable periods (a good crystal will maintain oscillation for a year will an accumulated error of less than 0.1 second). In a quartz clock or watch the alternating current from the oscillating circuit containing such a crystal is amplified and the frequency subdivided until it is suitable to drive a synchronous motor, which in turn drives a gear train to operate hands. Alternatively it is used to activate a digital display.

Quartz Iodine Lamp. A tungsten filament electric lamp moulded in a quartz envelope filled with iodine vapour. The working temperature is between 500° C and 600°C. Electric energy is converted to light much more efficiently than for the ordinary tungsten filament lamp.

Quartz Oscillator. A circuit whose resonant frequency of oscillation is stabilized by a Quartz crystal.

Quartz Wedge. A very thin wedge of quartz cut parallel to the optic axis by the use of which a desired thickness of quartz may be superposed on a mineral section in the polarizing microscope. It is used for determining the sign of double refraction of biaxial minerals from their interference figures in convergent light.

Quasars. A class of astronomical objects that appear on optical photographs as star-like but have large redshifts quite unlike those of stars. They werefirst observed in 1961 when it was found that strong radio emission was emanating from many of these starlike bodies. Over 600 such objects are now known and their redshifts can be as high as 3.53 The redshifts are characteristic of galaxies flying outwards from the centre of the universe at enormous speeds as a result of the expansion of the universe. This cosmological redshift is the explanation of the high observed redshifs of quasars favoured by most astronomers. Some, however,

maintain that the redshift could be a local Doppler effect, characteristic of movement relative to the earth and sun of nearby objects in the Galaxy, or a gravitational effect. If the redshifts are cosmological, quasars are the most distant objects in the universe, some being up to 10^{10} light-years away. The origin of quasars is unknown but what we observe now are the emissioms made by these objects 10^{10} years ago, when the galaxies are thought to have been forming. It has been suggested that the quasars may have been connected in some way with the birth of the glaxies.

The name quasar is a contraction of quasistellar objcet (QSO) or quasistellar galaxy (QSG). Quasars that are also radio sources are sometimes called quasistellar radio sources (QSS).

Quasi Particle. A system of many interacting particles which has particle like-properties but does not exist as a free particle, an example being a Phonon.

Quaternion. An operator, in a system of vector analysis invented by Hamilton, which changes one vector into another by rotation accompanied by a change of mangitude.

Quench. A capacitor or resistor or combination of the two placed across contacts, for example the make and break contacts of an Induction Coil, to inhibit sparking when the current is cut off to an inductive circuit.

Quenching

1. The rapid cooling of a metal by immersing it in a bath of liquid in order to improve its properties. Steels are quenched to make them harder but some nonferrous metals are quenched for other reasons (copper, for example, is made softer by quenching).
2. The process of inhibiting a continuous discharge in a Geiger counter so that the incidence of further ion-

izing radiation can cause a new discharge. This is achieved by introducing a quenching vapour, such as ether or a halogen gas, into the tube.

Quick Freezing. The preparation of foodstuffs for cold storage by passing them through the temperature zone of maximum ice-crystal formation (between about 0° and −4°C) as rapidly as possible to avoid damaging plant and animal tissues through the formation of large crystals.

Quiescent Current. The current flowing in a circuit when there is no applied signal.

Quiet Days : Calm Days. Five days selected each month as internatiyual magnetic "quiet" or "calm" days, on the basis of many magnetic observations.

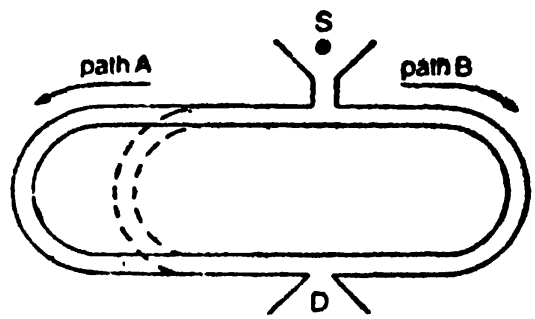
Quiet Sun. The term applied to the sun around the minimum of the sunspot cycle, when the absence of active regions allows relatively 'quiet' conditions of prevail. The sun is not then free of all disturbance but there are few (if any) concentrational of intense magnetic flux to produce significant departures from a uniform distribution of radiative flux across the disc.

Quiet Sun. The sun when it has a minimum of sunspots, flares or prominences.

Quincke Balance. A balance for the measurement of the magnetic susceptibility of a liquid from the change of liquid level in a U-tube in a strong magnetic field. The balance may also be used for a gas if the latter is placed in the U-tube above a liquid of known susceptibility.

Quincke's Tube. A device used to demonstrate the interference of sound. As shown in Fig. the single-frequency sound from source S can reach detector D by either path A or path B. If the path difference is an odd number of half wavelengths, the vibrations arrive at D out of phase and minimum sound results. If, however, the path difference is an integral number of wavelengths, reinforcement occurs and

a loud sound results. By moving the sliding tube a series of positions of maximum and minimum intensity can be obtained. By finding the average distance moved by the



Quincke's Tube

tube between consecutive minima; *i.e.* half a wavelength, the wavelength of the sound can be found and hence its speed.

Quintet, Spectral. A spectral line which is split into five as a result of spin-orbit interaction.

Q-Value. The amount of energy produced in a nuclear reaction.